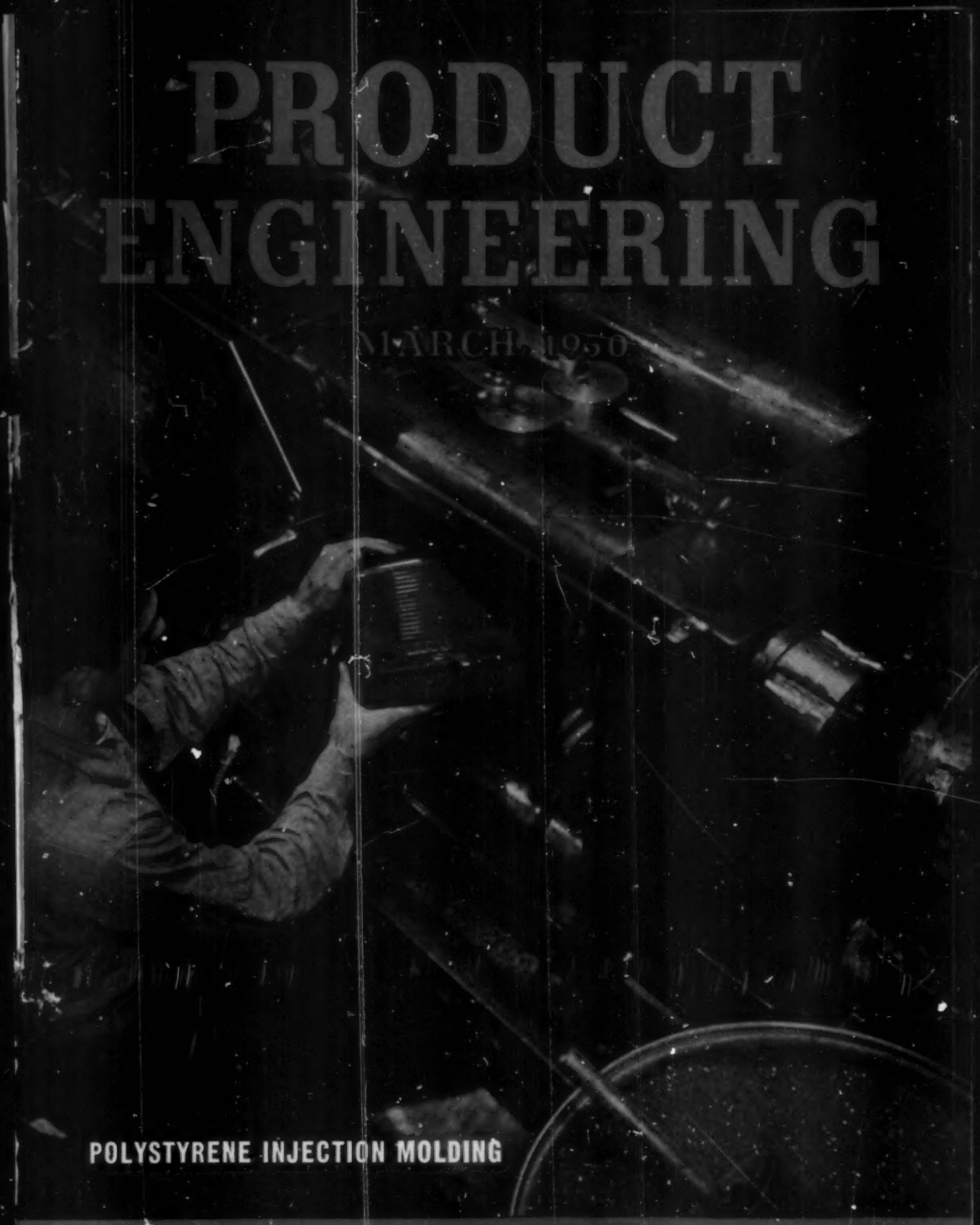
# PRODUCT ENGINEERING

MARCH, 1950



POLYSTYRENE INJECTION MOLDING

*IN THIS ISSUE*—Fluid Power Transmissions + Polystyrene + Mechanical Joints for Tube Assembly + Gear Design for General Use + Assembly by Rubber Crimping

A McGRAW-HILL PUBLICATION

*You Can Save*

# TIME...MONEY...TROUBLE

*with*

# CAST NICKEL ALLOY STEELS

A fundamental difference exists between alloy steel castings and those of plain carbon steel . . .

The *unmatched combination* of properties available in nickel alloy steels, cast to shape, assures superior performance, greater dependability and lower ultimate cost.

## MEET EXACTING REQUIREMENTS

Engineering requirements often call for castings with properties that are attainable only by heat treatment, Since castings are generally complex shapes and frequently vary in section thickness, simple normalizing treatments are often practiced. When quenching and tempering are necessary, substantial economies can result from using steels that adequately resist the tendency to warp and crack.

## RESPONSE TO HEAT TREATMENT

Cast nickel alloy steels provide basic advantages for fabricator and user, alike. Well beyond the reach of carbon steels are the combinations of strength or hardness and toughness which can be obtained in nickel steel castings by simple normalizing. Their response to mild quenching avoids distortion and cracking, thus permitting the attainment of high strength with adequate ductility in large, cumbersome sections. This simply can't be done with carbon steels.

## CONTROLLED IMPROVEMENT

Nickel additions permit controlled improvement of desired properties in steel. Such control has resulted in use of cast nickel steels in main frames for steam locomotives since the early part of this century. High toughness . . . and strength along with ductility . . . are primary requisites in railroad service. Significantly, railroads now are the largest tonnage users of nickel alloy steel castings.

## ADVANTAGES OFFERED

Extensive use in oil production, hydroelectric plants, steel rolling and forging, mining, milling, smelting and other heavy industries indicates growing recognition of the following advantages offered by alloy over plain carbon steel castings:

- **Stronger . . . higher yield strength**
- **Less bulk and deadweight**
- **Harder . . . more wear resistant**
- **Better response to heat treatment**
- **Greater shock-resistance**
- **Greater fatigue strength**
- **Less embrittlement at sub-zero temperatures**

## INFORMATION AVAILABLE

May we send you a copy of "Nickel Alloy Steel Castings in Industry". This edition, containing information for users, fabricators, engineers, designers and others, is yours for the asking. Write for it today.

EMBLEM OF INCO SERVICE

**THE INTERNATIONAL NICKEL COMPANY, INC.** 67 WALL STREET NEW YORK 5, N. Y.

VOLUME 21 **PRODUCT ENGINEERING** NUMBER 3

G. F. NORDENHOLT, *Editor*
*Assistant to the Editor,* Joseph Kerr • *Managing Editor,* James R. Bright • *Associate Editors,* Harold Schor V. H. Laughner • *Assistant Editors,* E. S. Cobb, J. D. Cooney, W. B. Eidson, P. F. Horbatt, N. J. Van Ness
*Consulting Editor,* Robert E. Bruckner • *Washington,* George B. Bryant, Jr.
*Publisher,* Albert Haupdi • *Assistant Publisher,* W. E. Kennedy
*Foreign News Bureau:* London • Paris • Berlin • Moscow • Tokyo • Bombay • Melbourne • Rio de Janiero • Buenos Aires

## *MARCH 1950*

**Increasing Use of Styrene Plastics** by Sanford E. Glick . . . . . 81
Physical, chemical, electrical properties of general purpose and modified styrenes.

**New Dry Cells** by Walter J. Hamer . . . . . 87
Characteristics and environmental properties of new cells and improved conventional types.

**Product Designs** . . . . . 92
Portable steam generator; Ceramic transformer core; Mechanical kidney; Fatigue tester.

**Determining Gear Tooth Surface Durability** by Davis M. Wood . . . . . 104
A new and thought provoking proposal for estimating the life of spur and helical gearing.

**Flush Head Screw Allowables In 24ST Alclad Sheet Joints** by Harold G. Brilmyer . . . . 109
Shear and bearing allowables for flush head screws are set up with recommendations for adoption.

**Fluid Power Transmissions** by C. L. Sadler and W. F. Shurts . . . . . 113
A detailed and comprehensive answer to such questions as: "Why use hydraulic transmissions? What basic types are available? What is the difference between a closed, an open, and a differential hydrostatic system and how can each system be arranged? Where are fluid torque converters used in industry? How do the various fluid converters and couplings on the market differ in construction and performance?" In short, here's what you should know before you apply hydraulics to your equipment.

**How D-C Synchros Work** by Robert A. Gerg and Charles R. Mikolic . . . . . 137
The new d-c positioners offer simple solutions to many remote control problems.

**Precision Mechano-Hydraulic Dynamometer** . . . . . 141
Positive control of torque-arm movements results in high-accuracy load measurements.

**Fifteen Types of Mechanical Joints for Tubing** . . . . . 142
Construction of butt joints not requiring welding are illustrated.

**Rubber Crimping of Thin-Walled Parts** by Frank R. Simpson . . . . . 144
Design of metallic parts that can be assembled by rubber crimping.

**Approximate Relative Costs of Various Spring Materials** by H. E. Machado . . . . . 161
Relative cost per pound vs diameter for various materials.

**Calculating Large Deflections of Cantilever Beams** by K. E. Bisshopp and D. C. Drucker . . . 163
Chart for calculating the horizontal and vertical deflections.

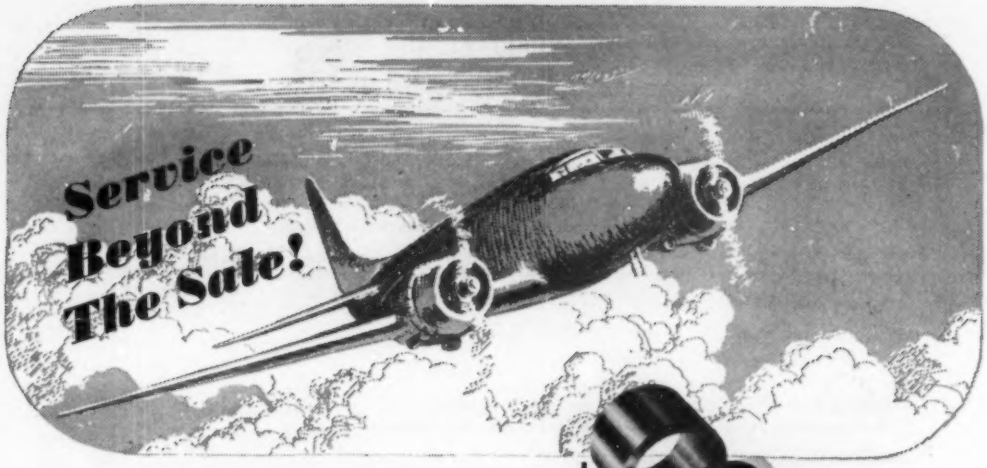
FRONT COVER—Philco radio cabinet containing 1.3 lb of heat resistant polystyrene (Lustrex LX) is injection molded by Worcester Moulded Plastics Co., Worcester, Mass., in a 32 oz press, with 1,000 psi hydraulic pressure on a 62-sec cycle. Kodachrome by Syd Karson, McGraw-Hill Studios.

DEPARTMENTS

Highlights . . . . . 3
Editorial . . . . . 79
Engineering Abstracts . . . . 149
New Components, Parts, and Materials . . . . . 164
Technical News . . . . . 152
Meetings . . . . . 202
Our Readers Say . . . . . 204
New Books . . . . . 210

**Publication Office:** 99-129 North Broadway, Albany 1, N. Y. Return postage guaranteed. **Published Monthly** by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder; James H. McGraw, Jr., President; Curtis W. McGraw, Vice-President and Treasurer; Eugene Duffield, Senior Vice-President, Publications Division; Nelson Bond, Vice-President and Director of Advertising; Joseph A. Gerardi, Secretary; J. E. Blackburn, Jr., Vice-President and Director of Circulation.
**Correspondence About Subscriptions** should be addressed to Director of Circulation, Product Engineering, 330 W. 42nd St., New York 18. Allow at least 10 days for change of address. Indicate position and company connection on all subscription orders.

**Subscription Rates:** Single copies 75c. United States and possessions, $6 for one year, $9 for two years, $12 for three years; Canada, $7 for one year, $11 for two years, $14 for three years; Latin American countries, $10 for one year, $16 for two years, $20 for three years; all other countries, $15 for one year, $25 for two years, $30 for three years.
**Editorial and Executive Offices:** 330 W. 42nd St., New York 18. Cable address: "McGraw-Hill," N. Y.
**Branch Offices:** ATLANTA, R. M. Maultsby, 1311 Rhodes-Haverty Bldg.; BOSTON, M. A. Williamson, Jr., 1427 Statler Bldg.; CHICAGO, Arnem E. Meanor, 520 N. Michigan Ave.; CINCINNATI, B. R. Anderson, 1110 Delta Ave.; CLEVELAND, A. F. Tischer and E. H. Anderson, 1510 Hanna Bldg.; DALLAS, J. H. Allen, First National Bank Bldg.; DETROIT, G. P. Weatherby, 2960 Penobscot Bldg.; LOS ANGELES, C. W. Dysinger, 621 S. Hope St.; NEW YORK, J. A. McGraw, Hugh Britton, 330 W. 42nd St.; PHILADELPHIA, David G. Jones, Architects Bldg.; PITTSBURGH, A. F. Tischer, 738-9 Oliver Bldg.; SAN FRANCISCO, J. W. Ostrander, 68 Post St.; WASHINGTON, National Press Bldg.; LONDON, Aldwych House, Aldwych, W. C. 2, England.
Entered as second-class matter Aug. 31, 1950, at Post Office, Albany, N. Y., under Act of Mar. 3, 1879. Printed in U. S. A.
Member of A.B.P. A.B.C. Copyright 1950 by McGraw-Hill Publishing Co., Inc. All rights reserved.




# Extra Savings in Design and Production...with *Mallory High-Density Alloy!*

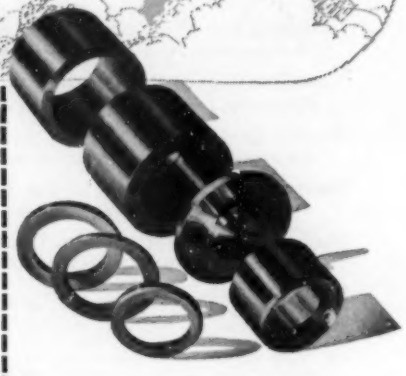
The list grows every day! Mallory non-ferrous alloys and ingenious applications are making big savings for more and more Mallory customers.

Here's an interesting example. Recently, a well-known manufacturer of aircraft instruments was faced with the necessity of increasing the stability of a gyroscope, in order to use it for larger planes. Plans included enlargement of the steel rotor . . . involved expensive re-tooling for the larger assembly. Mallory suggested that the rotor be made from readily-machinable, high-density Mallory 1000 Metal. Tests proved it to be ideal. The required stability was obtained with no increase in the size of the rotor or the gyroscope. Further . . . production delays and the expense of major re-designing were avoided.

*That's service beyond the sale!*

And whether your problem is metallurgical or electronic, what Mallory has done for others can be done for you!

*In Canada, made and sold by Johnson Matthey & Mallory, Ltd., 110 Industry St., Toronto 15, Ontario*



### *Mallory 1000 and Other Alloys*

Mallory 1000 is a high-density metal whose density approaches that of tungsten and platinum. It has great strength and is readily machinable. Its resistance to the corrosive action of many acids, as well as the atmosphere, is superior.

Mallory is a leading producer of unusual alloys and materials from copper, silver, platinum, palladium, tungsten, molybdenum, and other non-ferrous metals and alloys. Recently the line has been broadened to include certified pure copper, aluminum-bronze, nickel and nickel alloys. This places Mallory in a qualified position to make effective and impartial recommendations for materials best suited to your needs. Write today.

## Metallurgical Products and Alloys

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

**SERVING INDUSTRY WITH**

Capacitors
Contacts
Controls
Resistors
Rectifiers
Vibrators
Special Switches
Power Supplies
Resistance Welding Materials

# Highlights

**In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.**

## Metallic Materials

THE PERIODIC TABLE has been stretched another notch with the discovery of element 97 that has been christened berkelium. Short lived and very active, the super-heavy element is the third to emerge from the 60- and 184-in. cyclotrons at the University of California in Berkley. Americium and curium are the other progeny of these huge atom smashers.

TWO ALLOY SYSTEMS of high-strength magnesium are under close scrutiny in Air Force laboratories. Both the Mg-Zn-Zr and the Al-Mg-Zn-Mn systems boast yield strengths in excess of 40,000 psi and ultimates of more than 50,000 pounds per square inch.

SUPER-LOW TEMPERATURES have queer effects on magnesium as well as gold. As absolute zero is approached, the electrical resistance of these pure metals increases rather than decreases, much in the same manner as do semi-conducting materials.

LIQUID MOLYBDENUM, when used with or in place of standard lubricants, prevents failures is heavily-loaded, high-speed bearings. A special vehicle carries the "greasy" metal to friction surfaces where it "plates out" as an anti-friction coating. Stable up to 750 F, product refuses to be "squeezed out" of dies used in deep drawing operations.

LOW-CARBON STEELS take on hardnesses associated with the more expensive grades after treatment with a chromium-carbon powder. Just heat the the steel to a cherry red (1,400 to 1,600 F), dip it in the greenish-grey compound, reheat it, then quench it. A 1/32-in. case having a hardness of Rockwell C-60 results, yet there is no appreciable change in the part's dimensions.

SILVER-BEARING SOLDER for bonding aluminum to itself, steel, bronze and copper has a tensile strength of 11,000 psi, good corrosion resistance and high electrical conductivity. Bonding temperature of 650 to 700 F places alloy between plain and silver solders. Hardness is 60 to 70 Brinell.

## Nonmetallic Materials

HAIRLINE CRACKS that have long plagued designers of pressurized aircraft windows don't develop in a transparent thermosetting plastic now being tested. Makers claim material withstands rapid temperature and pressure changes, resists most standard cleaning compounds and mounting cements. Machining the sheets is no problem, but forming varies from standard procedures according to a part's requirements.

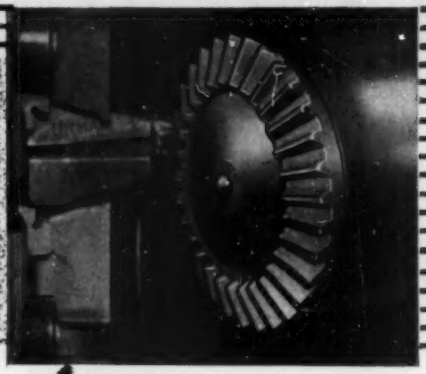
FLUORINE LUBRICANTS may knock the question "Check your oil?" right out of the gas station attendant's vocabulary. According to a recent report, it may soon be practical to design cars in which both the engine and gear oils, as well as chassis greases, need not be changed and would require infrequent checks.

GLASS-FIBRE TAPE for use as electrical insulation has a rubber-like dielectric on each side. One of the films is completely cured, the other only semi-cured. When heated at 260 F for 15 min, the second side "sets" to form a solid mass having a dielectric strength of approximately 550 volts per mil.

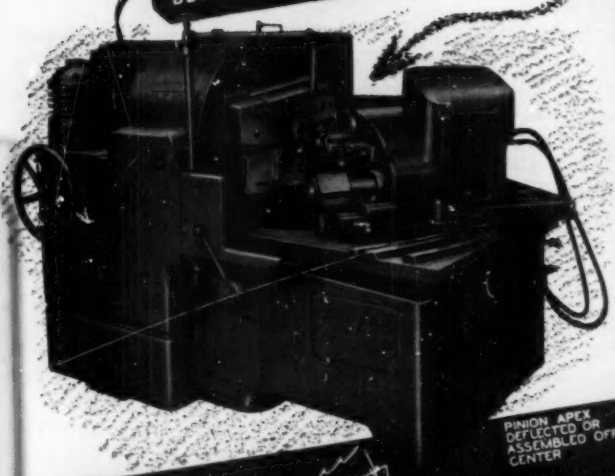
ANTI-STATIC COMPOUND puts plastics, textile fibres, door handles, inner tubes and glass on a "no charge" basis. Also reduces the accumulation of dust on such surfaces – television tubes, for instance. Liquid can be sprayor brush-applied, dries to form an invisible, non-inflammable film.

Continued on Page 5

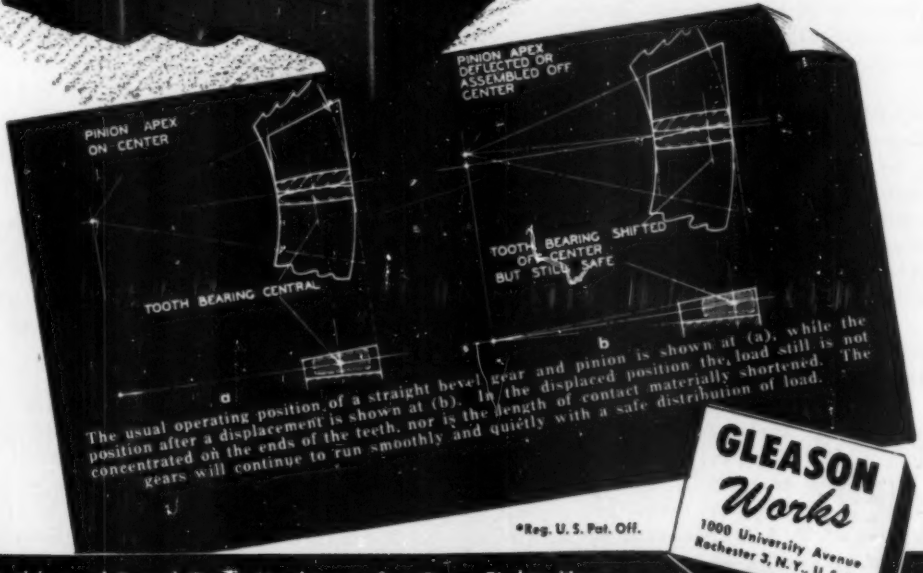
# DESIGNED *Especially* FOR CONIFLEX GEAR PRODUCTION



GLEASON
• No. 14 STRAIGHT
BEVEL GENERATOR



**Coniflex® gears, in the medium sizes, are produced on the Gleason No. 14 Straight Bevel Generator. Completely universal, this machine roughs and finishes Coniflex gears with equal versatility. The Gleason No. 14 Straight Bevel Generator is easier to operate and requires less cutting time than previous models for comparative gears. It also produces a localization of tooth bearing which makes Coniflex the smoother operating, easier assemblying gears with wider operating tolerances. Today, Coniflex gears have proven themselves superior to ordinary straight bevels. In saved assembly time, in superior operation, Coniflex gears are providing daily outstanding performance.**


PINION APEX
ON CENTER
TOOTH BEARING CENTRAL
a
PINION APEX
DEFLECTED OR
ASSEMBLED OFF
CENTER
TOOTH BEARING SHIFTED
OFF CENTER
BUT STILL SAFE
b
The usual operating position of a straight bevel gear and pinion is shown at (a), while the position after a displacement is shown at (b). In the displaced position the load still is not concentrated on the ends of the teeth, nor is the length of contact materially shortened. The gears will continue to run smoothly and quietly with a safe distribution of load.

*Reg. U. S. Pat. Off.

GLEASON *Works*
1000 University Avenue
Rochester 3, N. Y., U. S. A.

*Builders of Bevel Gear Machinery for Over Eighty Years*

A RICH SOURCE of ultra-violet light results from electrically-excited xenon sealed in a quartz tube under a pressure of twenty atmospheres. The xenon arc is twenty-five times as intense as the crater of a carbon arc generator.

BRITTLE POINT of a special silicone rubber is well below zero so that gaskets, diaphragms, sleeves and packings remain stable at continuous temperatures down to −110 F. The desirable corrosion resistance and electrical properties of rubber can now be utilized throughout the extended range up to 350 Fahrenheit.

## Components

RECTANGULAR TUBES of all-glass construction are appearing in several 16-in.-screen commercial television sets. 100 percent of the transmitted picture appears, the proportions being four units of width to three of height. This dimensional ratio parallels that of standard motion picture film.

FATIGUE FAILURES of steel retaining rings and washers used for positioning a connecting rod on the end of a crank pin have been stopped by substituting similar parts of different materials. Rubber O-rings and laminated phenolic washers filled the bill because the resiliency of each is sufficient to absorb pounding of the rod on the pin.

THIN METALLIZED PAPER is the secret to cutting the size of small electrical capacitors in half. Two layers of zinc-coated Kraft paper take the place of two sheets of aluminum foil and two pairs of paper insulators. The chemically-pure paper is coated with dielectric lacquer on one side and vacuum-impregnated zinc on the other.

SHIFTING from one speed range into another in trucks having two-speed axles isn't the chore it used to be, thanks to a motor-driven, overrunning drive screw mechanism. When the driver pushes or pulls a button on the shift lever, motor turns the screw and forces a nut up or down its thread. Changes in the tension of a spring attached to the nut cause the transmission to snap from one speed range to the other.

A 50 PERCENT INCREASE in the life of chain drives is attributed to long, specially-shaped sprocket teeth. Instead of having a standard curved contour, the working face of each tooth has a straight face and a topping curve at the tip. Advantages claimed are greater pitch elongation before chain fails to mesh properly on the teeth and more accurately finished teeth.

## Processes

CARBON PARTS are tough customers when it comes to joining them permanently. But two Englishmen have come up with a practical method. Place together the surfaces to be joined and pass a powerful electric current through them. The atmosphere around the joint must be non-oxidizing.

IN A FRENCH PROCESS for hot-forming steel, a modified hydraulic press is used for extruding tubes and complex shapes that can't be handled in a rolling mill. Those familiar with the technique claim many large carbon-steel parts can be replaced by lighter longer-lasting stainless parts at equal cost.

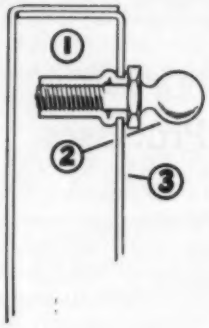
PRELIMINARY COATINGS of tin, hot-dipped or electroplated on electrical parts, make subsequent soldering operations simple. But if weeks or months elapse before the part is soldered, the tin oxidizes to the point of weakening the bond. Not so with a 40–60 lead-tin alloy plated from a fluoborate-boric acid solution and fused in molten palm oil. Tests show soldering with rosin flux nine months after plating is completely satisfactory.

SUPERHEATED STEAM is the latest vehicle used for spraying paint. High viscosity paints are no problem; pressures and temperatures can be widely varied. Runs rarely occur, because paint is evenly dispersed. 15 percent of material is saved.

COPPER-ON-ALUMINUM by a new plating method. Anodize two aluminum parts in a water solution of sulfuric acid and copper sulphate. Connect parts in parallel as cathodes and a body of copper as the anode. Then, using alternating current, plate copper on the parts.

Continued on Page 7

# 3 tough fastening problems solved by one RIVNUT!

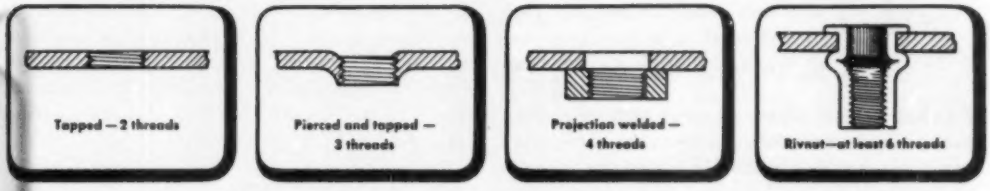



KITCHEN CABINET designers needed a rivet that 1) could be installed from one side only, 2) would serve as a nut plate for a knob attachment, and 3) could be installed *after* enameling. A B. F. Goodrich Rivnut proved the perfect answer.

A flat-head Rivnut was inserted in the enameled sheet metal door, and upset with an easy-to-operate heading tool. The knob of the catch was then threaded into the clean, still-intact Rivnut threads.

This simple solution saved many man-hours on this job. If you have a fastening problem, why not put it up to Rivnut engineers? Write to The B. F. Goodrich Company, Dept. PE-30, Akron, Ohio.

***Compare these 4 methods of putting screw threads in thin sheet metal***




***Rivnuts provide at least 6 clean threads in one simple operation!***

1. Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.

2. Rivnut is inserted—head firmly against work, tool at right angles to work.

3. Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4. After upset, Rivnut threads are still clean and intact, ready for screw attachment.

**B.F.Goodrich**

# RIVNUTS

*The only one-piece blind rivet with threads*

**SEND NOW FOR FREE RIVNUT DEMONSTRATOR**

Demonstrates with motion how you can use Rivnuts to fasten TO *and* fasten WITH. Explains construction, gives proved applications . . . Write for your free copy today to The B. F. Goodrich Company, Department PE-30, Akron, Ohio.

THE ADVANTAGES of both fusion welding and brazing are capitalized in a new welding procedure that entails special steel filler alloys for joining, without fusion, steel, cast iron and many nonferrous alloys. Heat at the weld-zone is one-third less than in fusion welding, thereby avoiding any weakening of the heated metal. Lower residual stresses and less warpage are the chief benefits.

# Testing

IMPROVED INSTRUMENT for X-ray analysis of a material's elements and structure contains a super-sensitive Geiger counter that is rotated around the sample by a precision drive mechanism. Intensities and angles of the rays as they emerge from the sample are automatically recorded on a strip chart.

EXPLODING ATOMS in radioactive materials are the heart of an automatic device that measures the thickness of any sheet material, either

metallic or nonmetallic. An electronic meter counts the number of beta rays that pass through the sheet and indicates intensities in terms of thickness.

LUBRICANT FILMS two-millionths of an inch thick can be studied in detail with an electron diffraction instrument. X-ray or chemical analysis expose only a single film; new device brings out additional "surface" films, heretofore unknown. Rapid analysis by this method may lead to many new and better lubricants.

SIMPLE OPERATION is the attractive feature of an ammeter recently marketed. No binding posts are used – just slip the current-carrying wire through an opening in the plastic case, turn a knob until an indicator light goes out and read the meter. Scale range is easily shifted from 10–24 amp down to as low as 0.1–0.24 amp by increasing the number of turns of wire passed through the opening.

REJECTION RATES for assembly lines can now be continuously monitored by a "quality control indicator." Counts of total units produced and quantity of rejects are recorded. If rejects exceed maximum allowable for a given operation, needle on color-banded meter moves from "green" to "red."

UNLIKE MOST GASES, oxygen is strongly attracted to a magnet. This property has been put to work in a special device that is sensitive to a few parts of oxygen in one million.

# Products

ANY TYPE OF SOLDERING, even brazing and silver soldering, can be done quickly and economically with a new conduction-heating unit.

Carbon tip of the 5-oz handpiece glows on contact with work and flux-core solder flows onto joint. Capacity is equal to that of a 450-w electric iron.

HUMIDITY CARDS impregnated with a water solution of cobalt chloride, plus additives, may replace the familiar silica gel indicators. Variation of the solution's concentration permits close control of humidities in definite ranges up to 90 percent. Blue spots appear when critical humidity is reached.

DUAL-FREQUENCY transmitter-receiver that fits the hand has been developed for Air Force rescue use. Powered by a pocket-size, mercury-type battery, unit handles both voice and code signals. Sealed assembly is virtually shockproof and withstands temperatures ranging from −50 to +160 Fahrenheit.

WATER REPLACES AMMONIA in a new absorption-type refrigerating machine, resulting in reduced costs and safer operation of air conditioning systems. Plain salt is the absorbent used in this relatively simple assembly that consists of two shells, a heat exchanger, a solution pump and auxiliaries.

"STRETCHABLE" RULER adjusts to various scales within its one foot length. Expansion or

contraction of a triangular coiled spring spaces intermediate points proportionally, 100 divisions per inch showing when spring is completely compressed. Problems of spacing, proportion and interpolation are naturals for this device.

GREATER EFFICIENCIES in worm conveyors are gained by reducing the amount of rotary motion imparted to the conveyed materials. By mounting stationary guide vanes between sections of the worm, more linear flow is produced.

## Makers of the NEW UNIVERSAL COFFEEMATIC

### POUR THEMSELVES A

# YEARLY SAVING of over $10,000.

## ON ANNEALING COSTS

To pickle and anneal the body of their new coffee pot was costing Landers, Frary & Clark, makers of the famous line of Universal appliances, $7.50 per M pieces. 5 anneals, which at first seemed necessary to produce the quality product for which Universal is nationally known, jumped the cost per M pieces to $37.50. Universal knew this was far too high and decided to do something about it.

Their metallurgist, in cooperation with Revere, studied the problem in detail and then proved their conclusions by exhaustive tests. It was found that by using Revere copper strip in a certain temper, 4 anneals could be eliminated. Now, after a draw of 7¾", the copper body is annealed once then spun into its finished shape. Based on current production, this has resulted in a saving of over $10,000.00 per year, plus an improved product. Additional savings also are realized through more simplified handling, and more economical finishing operations due to the reduction in the number of anneals.

To make such a deep draw while holding rejects to the absolute minimum would not be possible were it not for the fine quality and consistent uniformity of the gauge and temper of the copper used. The copper body is tin plated inside, while the outside is first nickel plated then chromium plated.

Because of the nature of this appliance, which makes coffee automatically to the individual's taste, then reduces the current to keep coffee at serving temperature, Revere copper was selected for its high thermal-conductivity. This makes it possible to brew the coffee faster and keep it hot longer, thus saving on current.

Perhaps Revere Copper or some other Revere Metal can be of help in developing or improving your product—cutting your production costs. Why not tell Revere about *your* metal problems? Call the Revere Sales Office nearest you today.

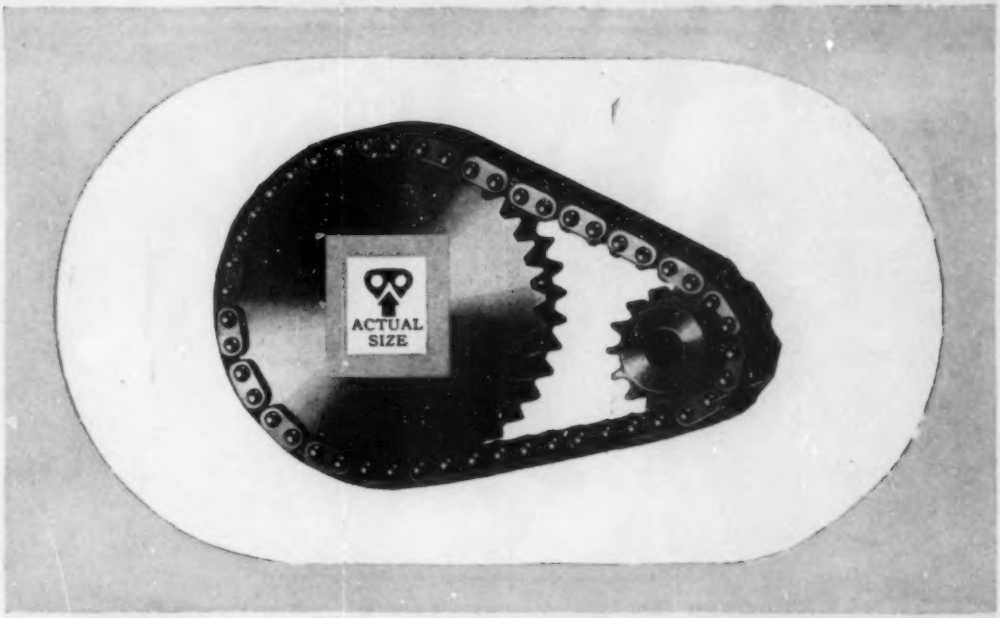
**REVERE**

**COPPER AND BRASS INCORPORATED**

*Founded by Paul Revere in 1801*

230 Park Avenue, New York 17, New York

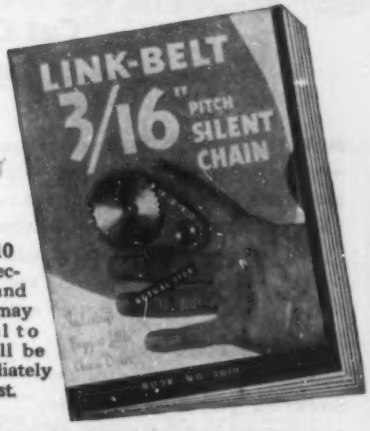
*Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.*
*Sales Offices in Principal Cities, Distributors Everywhere.*




# Industry's Biggest Little Chain Drive brings compactness, strength, flexibility to fractional horsepower transmission

The 3/16" pitch silent chain has been developed for designers who seek a positive, flexible, silent, high-speed drive for transmitting fractional horsepower. Made in three types: Middle Guide and Side Flange for shafts revolving in same direction; and Duplex type where shafts revolve in reverse directions. Patented coupler link and pin permit quick mounting or removal.

Our engineering staff will be pleased to confer with you concerning applications of the Link-Belt 3/16" pitch silent chain drive to your design.




**Book 2010** contains specifications and data which may be helpful to you. It will be sent immediately upon request.

**LINK-BELT COMPANY**

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities. 11,737

**LINK-BELT Silverstreak SILENT CHAIN DRIVE**

## Top Products in Every Line
## *Cut Costs and Build Sales*
## with AMERICAN PHILLIPS SCREWS

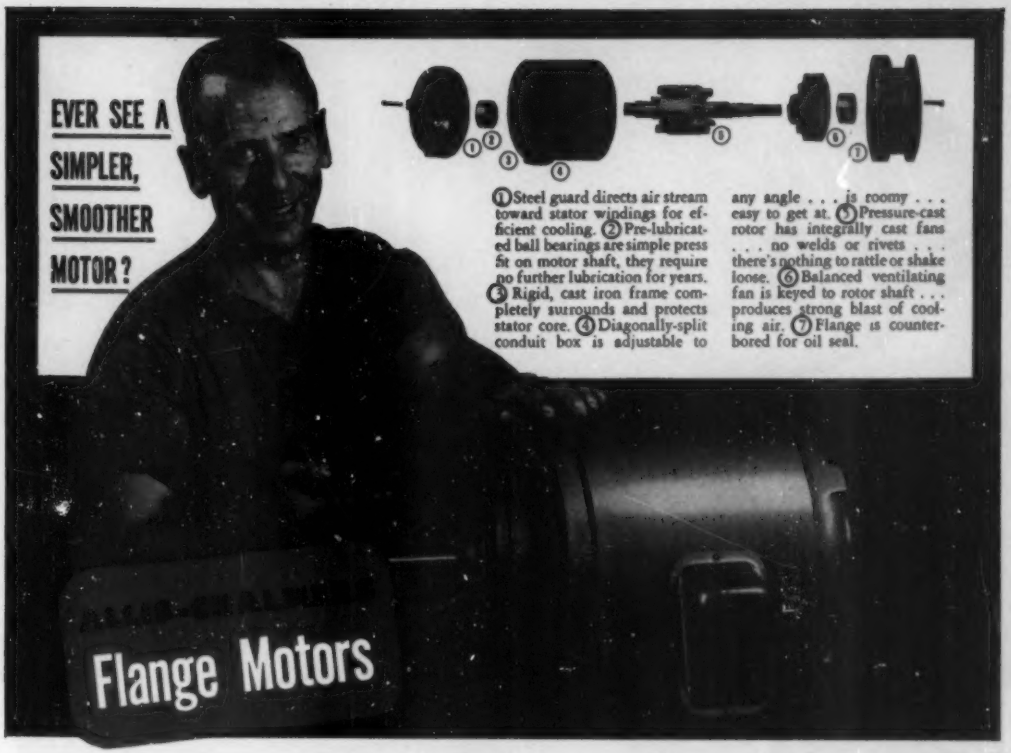
**HOW THEY CUT COSTS:** From vacuum cleaners to vending machines; from trucks to office appliances and suntan lamps . . . manufacturers use American Phillips Screws to speed up production, stop spoilage, and cut unit-costs. For these modern fastenings banish fumbling, crooked driving and scarred surfaces . . . *cut assembly time as much as 50%.*

**HOW THEY BUILD SALES:** On any product, the crossed-recess of American Phillips Screws is a "green light" to buyers who stop and look for an outward index of inward quality. They know that smooth-headed American Phillips Screws protect product-performance by staying tight and resisting vibration. Does *your* product have these two American Phillips advantages of cost-reduction and sales-promotion? No reason why it shouldn't . . . *for American Phillips Screws always cost least to use.* Write for proof.

**AMERICAN SCREW COMPANY, Main Office: Providence 1, R. I.**
**Plants at Willimantic, Conn., and Norristown, Pa.**
**Warehouses at: Chicago 11: 589 E. Illinois St. Detroit 2: 502 Stephenson Bldg.**

**AMERICAN PHILLIPS** *Screws*

**ALL TYPES**
**ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)**




① Steel guard directs air stream toward stator windings for efficient cooling. ② Pre-lubricated ball bearings are simple press fit on motor shaft, they require no further lubrication for years. ③ Rigid, cast iron frame completely surrounds and protects stator core. ④ Diagonally-split conduit box is adjustable to any angle . . . is roomy . . . easy to get at. ⑤ Pressure-cast rotor has integrally cast fans . . . no welds or rivets . . . there's nothing to rattle or shake loose. ⑥ Balanced ventilating fan is keyed to rotor shaft . . . produces strong blast of cooling air. ⑦ Flange is counterbored for oil seal.

# . . . meet Designer's Specifications!

CHOOSE *modern* flange motors that are real space savers. These motors "hug-up" tight against your machines . . . help eliminate problems of motor alignment . . . give your product that streamlined appearance that customers like.

And your customers can expect a *new low* motor maintenance from now on! That's because these *improved* Allis-Chalmers flange motors give them this 4-point motor protection:

1. PRELUBRICATED BEARINGS that need no attention for years.
2. RIGID CAST IRON FRAMES that can take hardest abuse.
3. MULTIPLE DIPPED AND BAKED insulation gives extra protection against heat and moisture.
4. ONE-PIECE PRESSURE CAST ROTOR has no rivets or welds . . . there's nothing to shake loose.

Allis-Chalmers Flange Motors are available in C and D flanges and P Bases, sizes to 150 hp. Mail the coupon for specification sheet containing ratings, dimensions, etc.

Whether you need flange motors or any type of motors, remember Allis-Chalmers! Also matching control for *any* motor.

ALLIS-CHALMERS

ALLIS-CHALMERS, 1002A SO. 70 ST. MILWAUKEE, WIS.
Please send me:

- ☐ Flange Motor Specification Sheet (5157324)
- ☐ Handy Guide to Electric Motors (5186052)
- ☐ General Purpose Motor Controls (1487132)

Name

Title

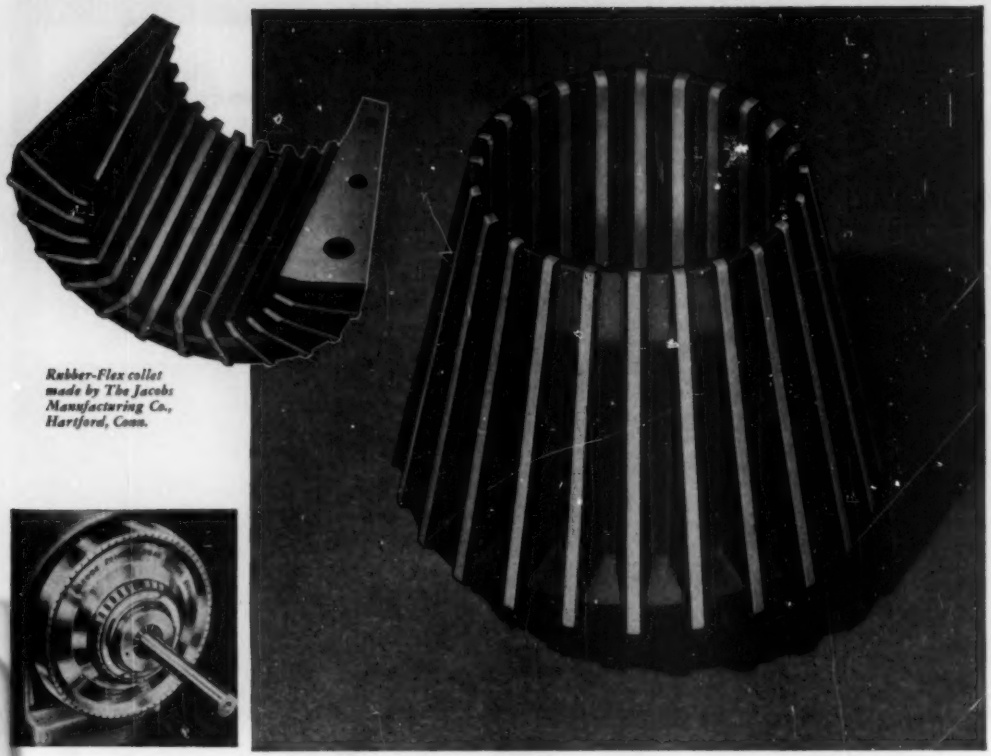
Company

Street

City State

A-2918

SOLD — APPLIED — SERVICED BY AUTHORIZED DEALERS, CERTIFIED SERVICE SHOPS, AND DISTRICT OFFICES THROUGHOUT U. S.



*Rubber-Flex collet made by The Jacobs Manufacturing Co., Hartford, Conn.*



# Does the work of 8 collets ...with HYCAR'S help!

MEN who know lathes say the new Jacobs Spindle Nose Lathe Collet Chuck is a world-beater. And one of the important reasons for its success is the Rubber-Flex collet—in which Hycar American rubber is a vital part.

This collet, pictured above, is made of hardened steel jaws bonded and mechanically locked together with Hycar. Each collet has a full ⅛" gripping capacity—making it possible for one Rubber-Flex collet to cover the range of eight split steel collets!

Here's why Hycar is fundamental in the chuck design: the rubber in the collet has to have excellent resistance to heat and to the deteriorating effects of coolants and cutting compounds. On both counts, Hycar fills the bill perfectly.

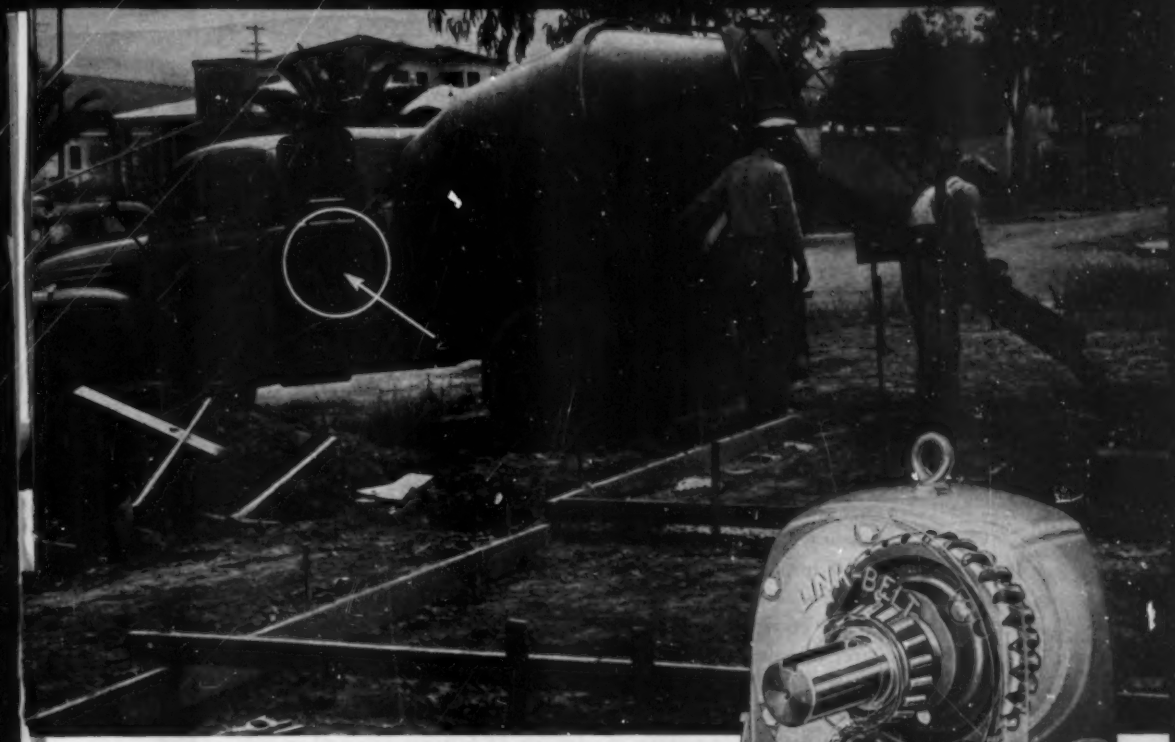
Another important point: Hycar's resistance to compression set makes it possible for the molded rubber to take *all* of the flexing action. Under tests—over four million individual openings and closings—there was no breakdown in the Hycar rubber or separation from the steel collet jaws. You can see what that means in long collet life under heavy duty use.

Use of Hycar in this unusual collet is another in a long series of product successes. For versatile Hycar is used as a base material . . . as a plasticizer for polyvinyl resins . . . as a modifier for phenolic resins . . . as an adhesive base . . . as a latex for coating or impregnating. Find out how Hycar may help you develop or improve products, profitably. Just write Dept. HL-2, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

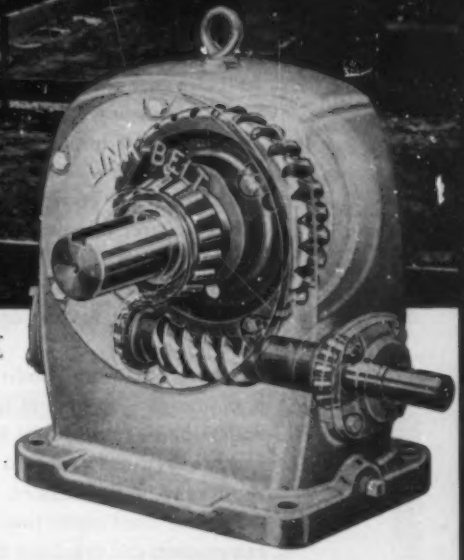
**Hycar** Reg. U.S. Pat. Off.
*American Rubber*

**B. F. Goodrich Chemical Company** A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers



Link-Belt Worm Gear and Roller Chain Drives on Challenge concrete mixer. (Solely distributed by Cook Bros. Equipment Co.) These Link-Belt Drives—compact, durable and efficient, meet the heavy demands of this rugged service.




# IF *the problem involves* *SPEED REDUCTION* LINK-BELT experience may help you

Any application for a speed reducer can be filled with a Link-Belt enclosed gear drive—and satisfactory results assured. Link-Belt manufactures all standard types, and Link-Belt power transmission specialists can offer reliable recommendations as to size and type to suit your precise need.

Herringbone Gear Drives for large reductions in limited space—high shock resistance—single, double or triple reductions. Send for Book No. 1819; Worm Gear Drives for high ratio reductions, horizontal or vertical drive shafts. Data in Book No. 1824; Link-Belt Gearmotors, self-contained power unit. Book No. 1815-A.

In respect to any drive in the broad Link-Belt line of power transmission machinery, Link-Belt engineering advice is completely unbiased.

11,759

LINK-BELT COMPANY Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities.

LINK-BELT

THE SYMBOL OF QUALITY — LINK-BELT — LB

Enclosed Gear Drives

# are you overlooking these bets in designing for lower costs?

In many cost reduction programs, too often the power transmission, timing or conveying method is taken for granted . . . the possibilities for cost reduction and improved performance overlooked. Equipment is redesigned . . . new equipment developed but with the same basic power transmission or conveying medium that has served for years.

In case after case, important savings in cost . . . increased efficiency have resulted when these basic functions have been redesigned. And that's where the complete Chain Belt line can help you. You can select the exact chain that best fits the operating conditions or horsepower and speed requirements.

Where operating conditions call for a cast chain, you'll find the exact type and size needed. If speeds and horsepower call for a finished steel roller chain, again you'll find the exact chain you need. Where loads are extra heavy or operation is in dusty, dirty locations, a steel Chabelco chain may be the answer.

Because their chain line is complete, Chain Belt Field Sales Engineers can recommend the chain that is right for your applications . . . for lowest overall cost. They are not handicapped by the restrictions of a limited line . . . can, without prejudice, recommend cast or steel chains in the size and type that are best for your machines.

Your Chain Belt Field Sales Engineer will be happy to review your chain selection and application problems. Or, if you prefer, simply fill in the coupon at the right for descriptive bulletins on the Chain Belt Company line.

CHAIN BELT REX COMPANY

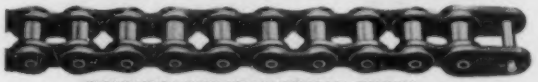
**CHAIN BELT COMPANY**

**REX CHAIN & TRANSMISSION DIVISION**
Milwaukee 4, Wisconsin

**BALDWIN-DUCKWORTH DIVISION**
Springfield 2, Massachusetts

**BALDWIN-REX ROLLER CHAIN** available in a complete range from ¼-inch to 2½-inch pitch for high speed power transmission and timing.

**BALDWIN-REX DOUBLE PITCH ROLLER CHAIN** for economical power transmission and conveying under slow speeds.



**BALDWIN-REX "BA" ROLLER CHAIN,** a new development in the larger pitch riveted chains with a single pin connector that makes assembly and disassembly easy.

**BALDWIN-REX LEAF (Cable) CHAIN,** an economical chain for lifting or pulling service particularly on hydraulic mechanism.

**BALDWIN-REX PLATE TOP CHAIN** for conveying bottles or jars where centers are long and loads moderate to heavy.

**REX TABLE TOP CHAIN** for conveying bottles, jars, cans, packages, small parts where smooth transfer and cleanliness are required.

**REX DETACHABLE CHAIN,** available in both pressed steel (shown) and cast types for light drives and conveyor service.

**REX PINTLE CHAIN,** a drive and conveyor chain used where long life due to greater bearing area is needed.

**REX H-TYPE CHAIN** for use extensively for drive and transfer service where the wide wearing shoes add life in sliding applications.

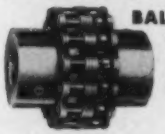
*These chains are representative of the complete Chain Belt Line. There are many other sizes and types as well as a complete range of chain attachments for every type of conveyor service.*

BALDWIN-REX

**REX COMBINATION CHAINS,** suitable for general elevating and conveyor work at slower speeds where low cost and high strength are needed.

**REX DROP FORGED CHAINS,** used for trolley conveyors or floor-type sliding conveyors.

**REX CHABELCO STEEL CHAINS,** available in a range of sizes from 1½-inch to 36-inch pitch for drive and conveyor service under moderate to heavy loads.



**BALDWIN-REX FLEXIBLE COUPLINGS** are shock absorbing, eliminate back-lash, are easy to install. Made in 5 styles for every coupling service.

**REX CAST TOOTH SPROCKETS,** made of close grained gray iron. For greatest resistance to wear, available in Rex Temperim.

**BALDWIN-REX CUT TOOTH SPROCKETS,** cut with special tooth form for maximum efficiency, quiet operation and long life.

**Chain Belt District Sales Offices**

| | |
|---|---|
| Atlanta | Midland |
| Birmingham | Milwaukee |
| Boston | Minneapolis |
| Buffalo | New York |
| Chicago | Philadelphia |
| Cincinnati | Pittsburgh |
| Cleveland | Portland |
| Dallas | Richmond |
| Detroit | Salt Lake City |
| Houston | St. Louis |
| Indianapolis | San Francisco |
| Jacksonville | Seattle |
| Kansas City | Springfield |
| Los Angeles | Tulsa |
| Louisville | Worcester |

CHAIN BELT COMPANY
1715 W. Bruce Street, Milwaukee 4, Wis.

*Gentlemen:*
I am particularly interested in.....

.....

☐ Please send me descriptive bulletins.
☐ I would like to have a Rex Field Sales Engineer call on me regarding my chain application problems.

*Name*.....
*Company*.....*Department*.....
*Address*.....
*City*.....*State*.....

TOLEDO, OHIO PLANT NO. 1

# 7

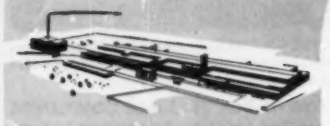
## LARGE AND MODERN DIE CASTING PLANTS

located strategically to give prompt, dependable deliveries, equipped with the most modern devices for reliable quality products, backed by 50 years' experience.

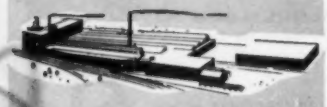
ONE OF OUR ENGINEERS will visit with you upon your request, to confer for best possible results.

OUR REPUTATION is your guarantee for satisfaction whether a small order or a large contract.

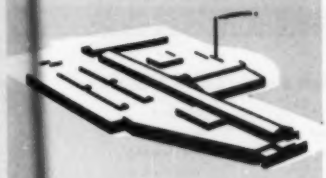
OUR RESEARCH DEPARTMENT offers its assistance for development work.



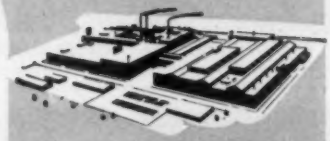
TOLEDO, OHIO PLANT NO. 2



POTTSTOWN, PA.
PLANT NO. 4

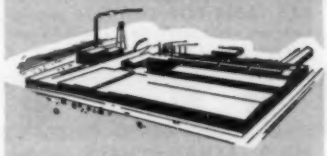


BATAVIA, N. Y.
PLANT NO. 6



GRAND RAPIDS, MICH.
PLANT NO. 3

BATAVIA, N. Y.
PLANT NO. 5



CHICAGO, ILL.
PLANT NO. 7

# DOEHLER-JARVIS CORPORATION

*The World's Largest Producer and Finisher of*

# DIE CASTINGS

EXECUTIVE OFFICES
386 FOURTH AVENUE
NEW YORK 16, N. Y.

*Cabinet molded for Zenith Radio Corp., Chicago*

# *Skillful Molding Creates*

## ITS NEWEST CABINET MEMBER

This cabinet which we molded for Zenith's new "Tip Top Holiday" portable is the latest in a long line of plastic cabinets molded by Mills. In shape—size—color—these cabinets have varied as widely as the products for which they were made.

All were alike however in one respect. Each was engineered and molded so that its attractive, sales appealing appearance was matched by sturdy durability.

The fact that we received additional cabinet molding jobs as well as other molding orders from the same clients proves we can be depended upon for top quality every time.

Let us show you today how our unique combination of sound engineering—careful, correct material selection and skillful molding can create a better plastic product for you.

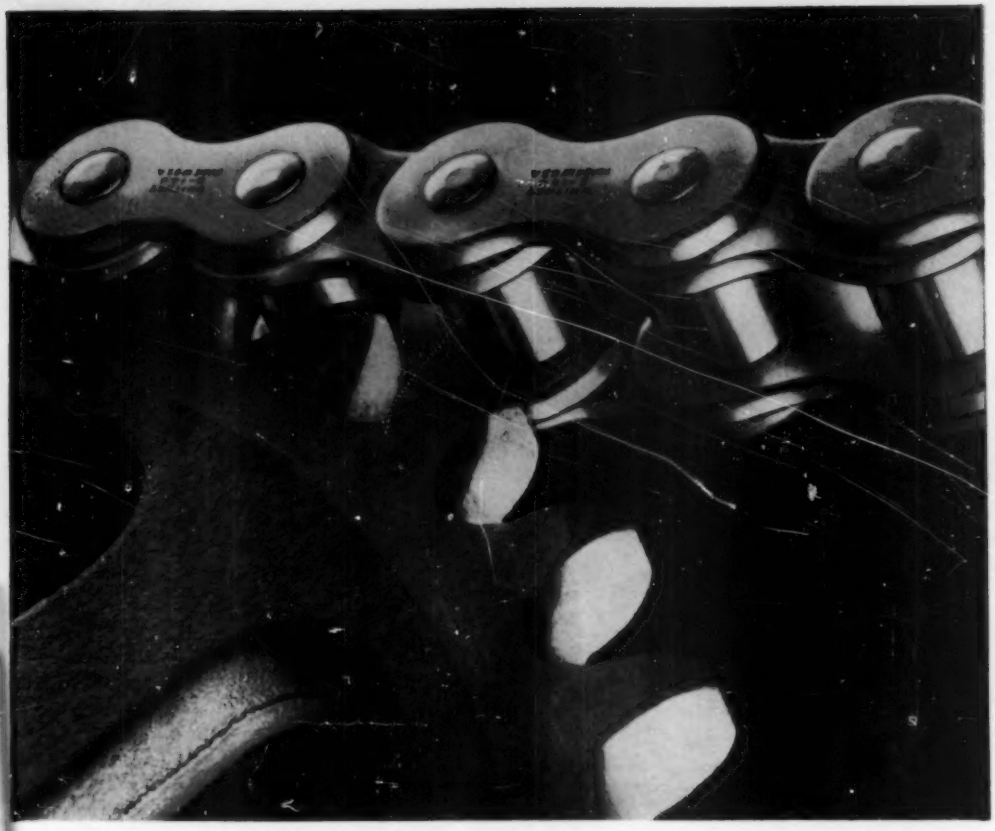
*Write on your letterhead for the new Injection Molded and Extruded Plastics Catalog. Or, for detailed information about CHEM-PLASTIC* piping, tubing and fittings, write for circulars containing data and illustrations.*

*Trademark registered

## ELMER E. MILLS CORPORATION

INJECTION MOLDERS and EXTRUDERS of: Tenite, Lumarith, Plastacele, Fibestos, Lucite, Nylon, Plexiglas, Polystyrene, Styron, Loalin, Vinylite, Geon, Plexene, Polyethylene, Carex, Fortical, CHEM-PLASTIC*, Saran, and other Thermoplastic Materials.

2930 NORTH ASHLAND AVENUE • CHICAGO 13, ILLINOIS



# A Portrait of Drive Efficiency and Savings

**Whitney Chain Drives cut transmission costs, provide positive grip, assure product uniformity**

Here's a close-up view of a Whitney Roller Chain engaging a sprocket tooth. Examine it carefully . . . by looking a little deeper, you can see power transmission efficiency and cost reducing design elements at work. Note the finely finished alloy steel rollers settling down to a positive, yet smooth engagement with the sprocket teeth . . . that's the all-steel combination, supplying the answer to countless drive problems.

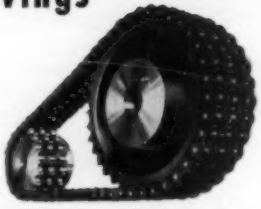
**Here are some of the reasons why:**

**Positive Grip** — Deeply seated in the sprocket teeth, Whitney Roller Chains transmit full rated horsepower without friction or slippage. This means constant machine output is maintained . . . highest transmission efficiency is always obtained.

**Versatility and Adaptability** — Because these roller chains operate on long or short centers, drive shafts clockwise or counterclockwise — separately or simultaneously, they simplify design problems, cut costs of complex drive mechanisms.

**Quality** — The acceptance of "Whitney" as a quality standard by designers of modern machines is the result of decades of chain making. Alloy steel parts are durably made — precisely assembled to stand up under the severest of operating conditions.

Whitney products are readily available through a nation-wide network of Whitney Distributors and Warehouses. Call the one nearest you for prompt service. For engineering assistance and catalogs write:



**OTHER WHITNEY PRODUCTS**

- Silent Chains — for smooth, high speed power transmission
- Conveyor Chains — for modern material handling
- Flexible Couplings — for positive but flexible direct drives
- Cut Tooth Sprockets — for smooth engagement, long life
- Whitney Woodruff Type Keys — for greater strength, easy assembly

**WHITNEY CHAIN & MFG. CO.**

*Division of Whitney-Hanson Industries, Inc.*

**204 HAMILTON STREET, HARTFORD 2, CONNECTICUT**

**Small Reset Counter:** Counts strokes or turns. Actual size is 2" wide, 1⅛" deep, less than 1" high. Built into business machines, coin machines, laundry machines, plastic molders, punch presses and many others.

**ANNUAL REPORTS** often show a surprising surge in sales . . . when Veeder-Root Counters are built into a product to give it an extra usefulness that makes customers take a new interest.

For Veeder-Root Counters put "Facts-in-Figures" to work in many ways . . . to prove a product's guarantee . . . to tighten control of production, inventory, purchasing . . . to spot errors, delays, waste . . . even to control machine-operation . . . and many other services that customers find desirable in any type of product.

Yes, there may be "hidden talents" in *your* product, too . . . talents for counting in new ways that will be helpful to *your* customers. And who's to say about this? Well, why not put it up to Veeder-Root engineers? They've discovered more unsuspected profits in more products than you could shake an Annual Report at! *Write.*

**Send for 8-page "Count Book"** that shows all types of Veeder-Root Counters for mechanical, electrical, and manual operation. Address:

**VEEDER-ROOT INC., HARTFORD 2, CONN.**

*In Canada:* Veeder-Root of Canada, Ltd., 955 St. James Street, Montreal 3.
*In Great Britain:* Veeder-Root Ltd., Kilspindie Road, Dundee, Scotland.

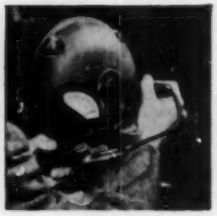
**Veeder-Root** **COUNTERS**

# Designer's

## 4 WAYS TO MEASURE MACHINE SPEEDS

**(AND PROTECT PRODUCT QUALITY, CUT MAINTENANCE TIME!)**

### 1 Hand



Check your machine output in jig time by using this General Electric hand tachometer to measure cutting speeds of lathes and milling machines, as well as linear speeds of planer beds, shapers and band saws. Accurate to ±1 per cent, it measures rotational speeds from 200 to 10,000 rpm (with accessories, 20 to 100,000 rpm), and linear speeds from 20 to 10,000 fpm. See Bulletin GEC-241.

### 2 Electric

Protect product quality that might be harmed by changes in machine speed with a G-E electric tachometer equipment. Available types can measure rotational speeds in many ranges, from 0–10 up to 15,000 rpm. Tachometer-generators may be mounted directly on or belted to the shaft being measured. A wide variety of instruments, calibrated in rpm, is available to indicate or record the voltages produced. See Bulletin GEA-4324.

GE Tachometers

### 3 Electronic

Where high accuracy is a "must," use a General Electric electronic tachometer. With either a phototube or tachometer-generator for input signals, it gives you accuracies as high as 0.1 per cent—keeps tabs on frequency, and on rotating, oscillating or translating speeds over a range of 0 to 60,000 rpm. See Bulletin GEC-224.

### 4 Special

For out-of-the-ordinary measurement involving extremely high speeds and accuracies, use a General Electric precision counter tachometer. Exceptional range (500 to 400,000 rpm) and accuracy (±0.025 per cent) makes it ideal for testing efficiency of high-speed machines like turbines and compressors—to save fuel cost, cut maintenance time. Included are speed pick-up, electronic unit, and indicator (illustrated). See Bulletin GEC-560.

GENERAL ELECTRIC

# Digest

PRODUCT HIGHLIGHTS

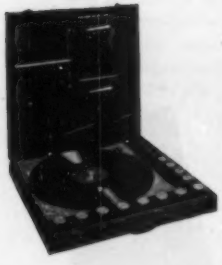
## WHEN A PROCESS NEEDS A PUSH

• Here's a simple, efficient unit for operating clutches, brakes, levers and valves—the General Electric Thrustor. Smoothly and dependably, it produces a straight-line push through a given stroke, replaces treadle mechanisms, decreases operator fatigue, ups production. Adaptable to remote or automatic control, it's uniform in action, ideal for repeat-operation uses. Available in 10 standard models (largest one shown) producing 50 to 800 lb thrusts, in 2- to 16-inch strokes. **See Bulletin GEA-1614.**

## PUT ON THE HEAT —*electrically*

If a machine or process needs a "spot" or "zone" of heat here and there, why become involved in complicated piping and expensive equipment? Simply specify the right type of G-E electric heater for clean, convenient, easily-controlled heat. The broad range includes immersion, strip, cartridge, tubular, fin, cable and unit heaters. A comprehensive 64-page booklet gives you complete data on each type, including applications, features, dimensions and prices. **Ask for Bulletin GEC-1005.**

## INDUSTRIAL ELECTRONICS —*explained visually*



Because of the many new opportunities it opens up for product improvement, electronics is almost "must" knowledge for designers today. To provide a quick but thorough grasp of the subject, General Electric offers a visual training course in industrial electronics. It covers practical applications such as relay systems, d-c motor control, rectifiers, etc. Complete with durable case, the kit includes 12 half-hour slidefilms, review booklets, and an instructor's manual. **See Bulletin GEA-5339.**

## It's new! It's a beauty! It belongs on your machine!

## Single-Phase Capacitor Motor

Where customer eye appeal counts in the equipment you make—in various compressor drives, in water pumps, in small shop and home machine tools, in farm equipment—build in General Electric's new Tri-Clad single-phase capacitor motor. Streamlined for looks, it has these four big features:

**Compact build and lighter weight**—to save space and shipping costs. In this Type KCS motor, outside capacitor housing and conduit box are eliminated. New motor is 15 to 20 per cent lighter than the old.

**Dependable new transfer mechanism**—for smooth steady starts. Totally enclosed transfer switch protects contacts from foreign matter.

**Long-life ball bearings**—to reduce upkeep. Grease chamber is easily filled through a grease-gun fitting in the end shield.

**Easy-to-wire terminals**—to cut installation time. All connections are on one easy-to-get-at terminal board inside the end shield.

Ratings (½ to 5 hp), frame sizes, mounting dimensions and shaft heights all follow NEMA standards. **See Bulletin GEA-5401.**

**General Electric Company, Section F668-77**
**Apparatus Department, Schenectady 5, N. Y.**

Please send me the following bulletins:

- ☐ GEA-1614—Thrustors
- ☐ GEA-4324—Electric Tachometers
- ☐ GEA-5339—Industrial Electronics Course
- ☐ GEA-5401—Single-phase Motors
- ☐ GEC-224 —Electronic Tachometers
- ☐ GEC-241 —Hand Tachometers
- ☐ GEC-560 —Precision Counter Tachometer
- ☐ GEC-1005 —Electric Heaters & Heating Devices

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

Name.....

Company.....

Street.....

City..... State.....

# No one type of speed control unit can be all things to all machines!

REEVES—with the widest application experience of *any* manufacturer in the specialized field of speed control engineering—knows as well as you do that no *one* type of unit can be the most efficient solution to *every* speed control problem encountered by machine designers and builders. That's why REEVES offers you a complete line . . . *three* separate and distinct types of units . . . all incorporating the same time-tested REEVES operating principle, but each possessing *different* features of design and construction to meet the individual requirements of individual machine builders.

All three REEVES units are available in the widest range of designs, sizes, speed ratios and controls . . . to assure you the *right* unit for every machine . . . the *right* speed for every operation and every operator under every changing condition.

Proof that machine designers and builders want this greater "selectivity" offered only by REEVES is reflected in the 2,100 different makes of machines on which REEVES is already standard equipment . . . and in the 265,000 successful REEVES installations in more than 25,000 industries.

REEVES maintains a nation-wide network of experienced speed control specialists. We suggest that you write for the name of the REEVES representative nearest you. He will be glad to meet with you and discuss your particular speed control problem—without obligation. And you can be sure that your REEVES Speed Control engineer will make completely unbiased and impartial recommendations concerning the unit best suited to your needs . . . because REEVES makes the *complete* line!

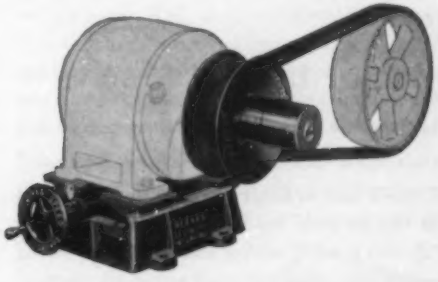
**FREE!** Entirely new, 132-page general catalog containing comprehensive information—plus hundreds of diagrams and illustrations—on the complete line of REEVES Variable Speed Drives and Controls. Essential to every designer, manufacturer and user of machines requiring variable speed control. Write today for Catalog No. K33-3N.

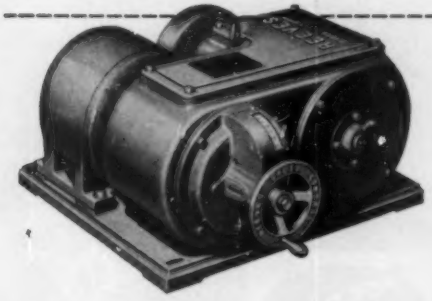
**REEVES PULLEY COMPANY • COLUMBUS, INDIANA**

# -that's why Reeves gives you a choice of 3*

* **Transmission** (left), extremely rugged in construction, is especially desirable for installations where the demand is for heavy-duty service, higher horsepower output, wide speed range, automatic control, etc. "Internal operating parts" ideal for incorporation within the machine framework as standard equipment. Transmission provides infinite, accurate speed flexibility over a range of 2:1 to 16:1. Sizes—fractional to 87 hp.

* **Motor Pulley** (right), most practical in installations calling for economy, limited speed range, ease of installation, low horsepower output, etc. Provides an instantly variable speed drive within 4:1 ratio for any constant speed motor. Sizes to 10 hp.





* **Motodrive** (left), ideal for installations indicating compactness, low output speeds, etc. Combines motor, speed varying mechanism and reduction gears in single unit. Speed variations 2:1 to 6:1 inclusive. Sizes to 20 hp.

*Recognized Leader in the Specialized Field of Speed Control Engineering*

ACCURATE · VARIABLE

**Reeves Speed Control**

GIVES THE RIGHT SPEED FOR EVERY JOB!

# tape that can take it

**You don't exactly buy tape to kick it around,**

**BUT—**

**—BUT you'll have to admit that most woven tapes do have to take an awful beating. For years nobody has come up with a better answer than "metallic" woven tapes—with little strands of metal woven into them.**

**BUT here's something far better—PHOENIX WYTEFACE† *non-metallic* Woven Tapes—a great and radical forward stride in tape development.**

**As one highway engineer puts it: "*it has at least three times the life of ordinary metallic tapes.*"**

**PHOENIX WYTEFACE has been given the works in grueling field tests—in extremes of climate, in water and mud, over stones and rocks, under truck wheels, through brush and barbed wire—and has come through shining and unscathed.**

**The secret is, this tape is a weave of amazingly strong synthetic yarns—a scientific wartime development—completely covered by an armor-like plastic coating that is not affected by water, is not brittle, will not flake.**

## MORE ACCURATE, TOO

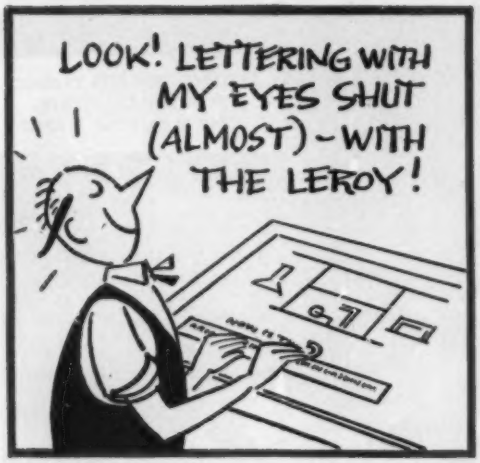
**Even after repeated soaking and dryings, this tape won't let you down. It has dimensional stability a lot greater than so-called "metallic" woven tapes.**

**And it has a HIGHER DIELECTRIC CONSTANT—which is important to power and utility companies and to anyone working near high tension circuits.**

**The clear black and red markings on the white background almost read themselves out loud, and the surface easily wipes clean as a whistle.**

†Trade Mark. U.S. Pat. 2,332,320.

## PHOENIX WYTEFACE




## beautiful lettering with little effort

Many engineers make perfect drawings and then mess them up with "home made" lettering. A quick easy way to get lettering and symbols which look like type on your drawings is to use a LEROY* "controlled lettering" outfit, a Keuffel & Esser Co. product.

THE MAN WHO HAND LETTERED THIS LINE

DID THIS WITH A LEROY LETTERING SET.

And he had had little experience with LEROY, and it took him no more time.

He didn't even have to rough it in with a pencil or draw guide lines. He chose one of several alphabets (templates) in his kit and followed the character grooves with an easy stroke of the scriber. Then the pen formed perfect letters right where he wanted 'em. A blind man could darned near do it!

LEROY lettering is free from risk of smearing, because the template is well removed from the lettering, and, there's no need for erasing. You have a wide choice of sizes and types of lettering, numerals and symbols.

## a tracing paper for the ages

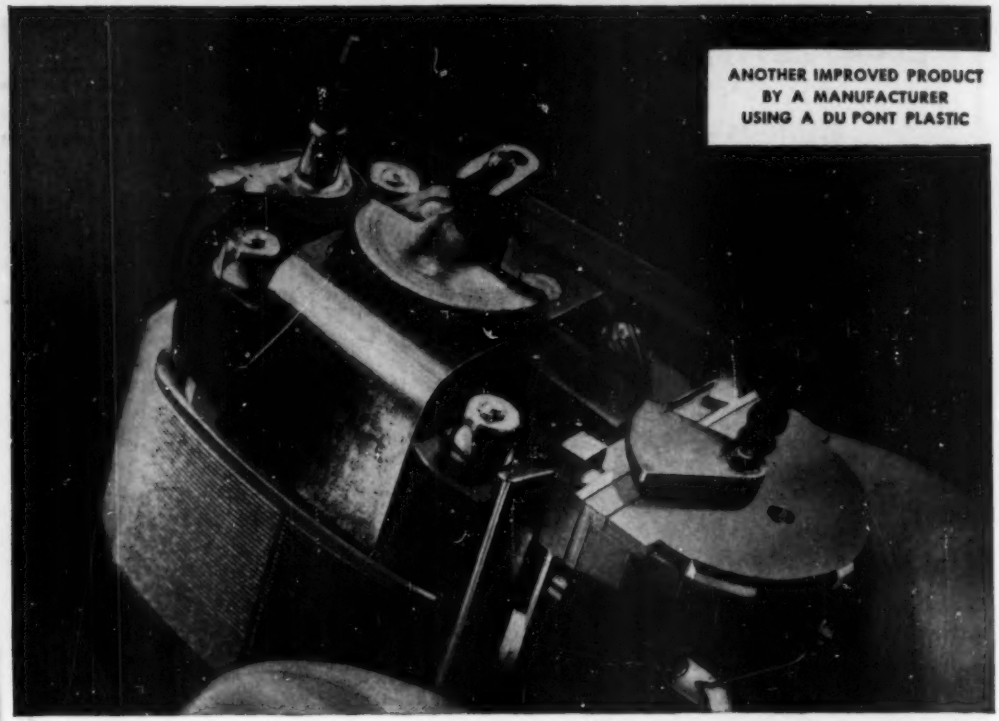
You practically want to think of posterity when you buy tracing paper. Well, there are drawings around today that were made years and years ago on ALBANENE*, and they are today as crisp and sharp as you could ask—which proves that ALBANENE does not turn brittle or lose its transparency with time.

You see, ALBANENE's transparency is due not to oils that leak and "bleed", but to a synthetic transparentizer that K&E developed specially for this purpose—and not for flavoring popcorn.

*Trade Mark

Ask your K&E Distributor or Branch for further information on any of these fine products, or for a sample length of PHOENIX WYTEFACE. Or write to Keuffel & Esser Co., Hoboken, N. J.

K&E
partners in creating
For 85 years K&E equipment and materials have been partners of the draftsman, engineer, and scientist in shaping the modern world.




# NYLON PLASTIC DRIVES NEW ELECTRIC SHAVER

*Connecting rod and three other parts of molded Du Pont nylon improve shaver operation . . . minimize need for lubrication*

IN DESIGNING their new electric shaver, the Sunbeam Corporation sought the best possible material from which to produce the connecting rod used to transmit power from the motor to the cutter blade. This part has to reciprocate at speeds from 15,000 to 17,000 half-cycles per minute. It has to prevent transmission of shock from the cutter blade to the motor shaft. It has to be light enough to keep vibration at a minimum. And it has to give long, trouble-free service.

After testing essentially every material that had any possibility of meeting these requirements, Sunbeam selected Du Pont nylon plastic. Weighing only one-eighth as much as metal, nylon provides the necessary strength, toughness, resiliency. It absorbs vibration and shock. And, cored with a 1/16" hole packed with a small amount of grease, the nylon connecting rod is ready for ten years or more of perfect operation without further lubrication.

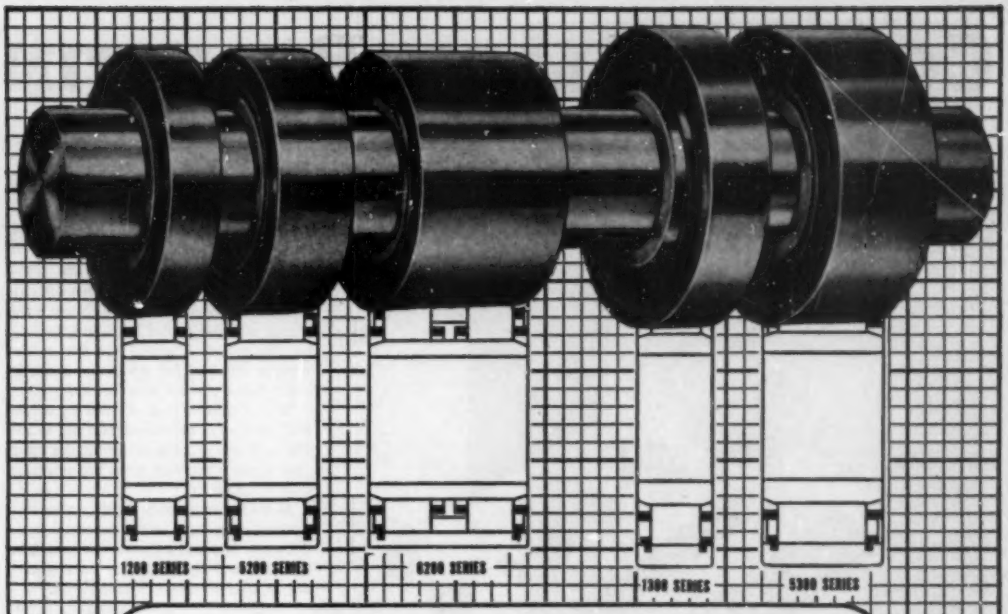
Three other parts of molded nylon are used in the new Sunbeam shaver. All play their part in speeding production, lightening weight and improving shaver performance.

Look into molded nylon parts for improving your product and its production. Nylon offers cost savings over other materials in many cases because of rapid, mass-production injection-molding, lightness of weight (which makes it cheaper than metals on a volume basis), and superior performance. In moving parts, nylon provides quiet operation either with no lubrication or with less than that required by other materials. Write for the facts today. We'll gladly suggest suppliers of molded nylon parts . . . gladly work with you in developing nylon parts to fit your needs.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Plastics Sales Offices: 350 Fifth Ave., N. Y. 1, N. Y.; 7 S. Dearborn St., Chicago 3, Ill.; 845 E. 60th St., Los Angeles 1, Calif.

*Nylon parts for Sunbeam Model W Shavemaster by Chicago Molded Products Corp., 1024 N. Kolmar Avenue, Chicago 51, Ill.*

**Tune in Du Pont "Cavalcade of America"—Tuesday evenings—NBC—coast to coast.**




# 5 TYPES—1 SHAFT SIZE

## "It's easier with HYATTS"

**As a designer, your job is made easier when you have a large selection of bearing types from which to choose. Here are five Hyatt Hy-Load Bearings . . . all different in size and load carrying capacity . . . yet all fitting a common shaft.**

**If the loads are light you may economize in space, cost and weight by using the narrow width bearings of our medium (1200) series.**

**Should the loads be heavy and the permissible outside diameter limited you can choose from the wide or duplex width (5200-6200) bearings of this same medium series.**

**When you have a condition where the loads are heavy and the axial space is not available, increased capacity can be provided by increasing the annulus size and using the 1300 or 5300 series bearings.**

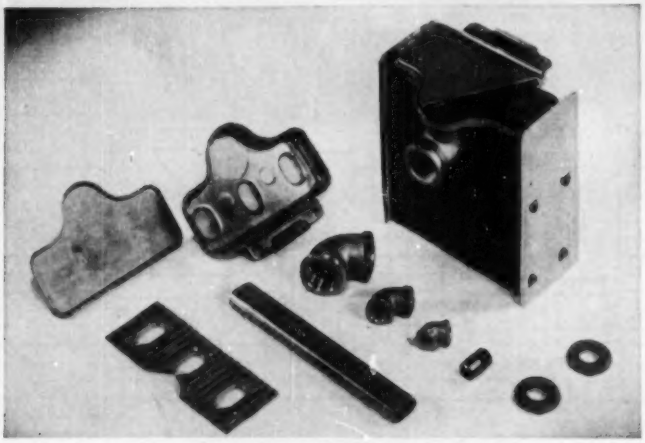
**These five combinations, available in most standard bearing bore sizes, illustrate just one of the many types and sizes of Hyatt Roller Bearings as shown in our new Hy-Load bearing catalog. Want a copy? Hyatt Bearings Division, General Motors Corporation, Harrison, N. J., Chicago, Detroit, Pittsburgh and Oakland, Calif.**

HYATT ROLLER BEARINGS

# COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

*Prepared Each Month by BRIDGEPORT BRASS COMPANY* "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Cutaway section of convector element and component parts — courtesy Tuttle & Bailey Inc., New Britain, Conn.

## Size of Convection Heaters Reduced by Using Copper

The ability to conduct heat at a rapid rate and to withstand corrosive attack has made copper an integral part of convection-type heating systems. Cool air comes in contact with the heating unit, rises when heated and sets up convection currents which perpetuates this cycle.

For the highest efficiency it is necessary to have a large area of heated surface. This is accomplished by extending the heating surface of the tubes by attaching thin sheets of copper to the tubing carrying the heating medium.

### High Heat Transfer

The heat in the tubing is speedily transmitted to the entire area of the fins which heat the air by contact. It is here that the high conductivity of copper comes into play. Despite the cold air coming into contact with the fins, they remain at practically the same temperature as the tubing carrying the hot water or steam.

The unit manufactured by Tuttle & Bailey Inc., New Britain, Conn., has oval copper tubing. The two heads which form the inlet and outlet ends of the radiator are fabricated from copper sheet. The inlet and outlet connectors are brass castings; however, they merely carry the heating medium to and from the element.

By using copper for the tubing and heads, high heat transfer characteristics are assured through the minimizing of corrosion. Any corrosive film acts as an insulator, reducing the flow of heat through the metal to the fins.

### Soldering Fins Simplified

A clever method of attaching the fins to the three tubes in the heater shown was devised. The fin sheets are dropped between steel plates in a jig with the proper spacing. Steel points are inserted into the front ends of the tubes. Then solder wire is put into holes in the points and the tubes are hand started into the first plate. An air cylinder then forces the tubes through the plates and the solder is pulled through by the tubes. A space for the solder wire is allowed for when the holes in the fins are pierced and formed.

The solder is then melted by a special method of electrical heating. While the next one is being soldered, the operator washes the flux from the previous unit by dipping.

Not only is greater rigidity obtained by soldering but a metal-to-metal bond between fins and tubes is assured. The fins are strengthened by corrugation which also increases surface area.

### Stampings Used for Heads

The heads are fabricated in two pieces. One part is a drawn shell and has the holes pierced and drifted to take the tubes and the connector. A second part is the end plate which fits into the drawn shell. The high ductility of the copper makes the drawing and forming operations relatively simple.

Phosphor copper brazing rod is used to join the connectors and tubes to the head as well as sealing the end plate.

Many such installations are built into walls, especially if put in while the house is being built. Standing units are also used. The long life of the copper eliminates costly maintenance which would be entailed if another metal of less corrosion resistance were used.

### Small Units Possible

Small units are possible by fabricating end heads to replace bulky castings. At the same time, the high conductivity of copper also permits less bulky units with greater heat transfer efficiency.

Where multiple operations are performed on sheet metal, Bridgeport's Laboratory is prepared to lend a helping hand to the designer in selecting not only the correct alloy, but the temper best suited for the job.


BRASS · BRONZE · COPPER · DURONZE — STRIP · ROD · WIRE · TUBING

MILLS IN
BRIDGEPORT, CONNECTICUT
INDIANAPOLIS, INDIANA
*In Canada:*
*Noranda Copper and Brass Limited, Montreal*

BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONNECTICUT
*Established 1865*
"Bridgeport" *District Offices and Warehouses in Principal Cities*

NATIONAL OIL SEAL LOGBOOK

## *The Function of "O" Rings versus the Function of Oil Seals*

"O" Rings are essentially a pressure sealing member designed primarily for use on reciprocating shafts and as static gaskets in a wide variety of mechanical devices. Where rotating applications are involved, "O" Rings are not recommended except for partial rotation as, for example, in a swivel joint. "O" Rings are used extensively in hydraulic and pneumatic systems—often in conjunction with various types of oil seals.

Most oil seals are used on rotating and oscillating shafts. However, they are available in a wide variety of designs in both springless and spring-tensioned types. Where pressures are not too great, some of the springless types are ideal for use on reciprocating shafts either as fluid seals, shaft wipers or dirt excluders.

A typical application of "O" Rings in conjunction with oil seals is shown in Fig. 1. In this case a face type oil seal is fitted to a rotating member effecting a closure around a stationary shaft sleeve. The "O" Ring is employed as a static gasket between shaft and internal bearing race.

Another similar application, Fig. 2, employs a spring-tensioned unitary oil seal in conjunction with an "O" Ring.

Illustration Fig. 3 shows use of "O" Rings as pressure seals and as static gaskets as well as the use of a springless type oil seal as a dirt excluder on the reciprocating shaft of a hydraulic pump. Note use of leather back-up rings (a) which protect "O" Rings from extruding effect caused by extreme pressures and reciprocal action.

National Oil seal engineers are ready to assist you with any sealing problems. "O" Rings of AN quality or commercial grade will be supplied by the Arrowhead Rubber Company Division. Oil seals having Syntech sealing members or using special "Nationalized" leather are available in hundreds of types and thousands of sizes, or special designs will be developed if needed.

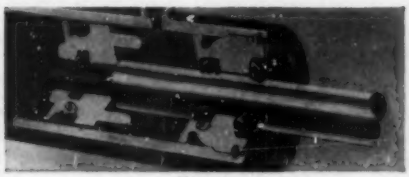


Figure 3

**CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS**

| | |
|---|---|
| BUFFALO, N. Y. | 56 Arlington Place, Grant 2280 |
| CHICAGO, ILL. | Room 2014 Field Building, Central 6-8663 |
| CLEVELAND, OHIO | 210 Heights Rockefeller Bldg., Yellowstone 2720 |
| DALLAS, TEXAS | 30½ Highland Park Village, Justin 8-8453 |
| DETROIT, MICH. | Room 1026 Fisher Building, Trinity 1-6363 |
| HOUSTON, TEXAS | 6731 Harrisburg Boulevard, Wayside 3-1246 |
| LOS ANGELES, CALIF. | 2244 East 77th Street, Kimball 6384 |
| MILWAUKEE, WIS. | 647 West Virginia St., Marquette 8-8986 |
| NEW YORK CITY, N. Y. | 122 East 42nd Street, Lexington 2-8260 |
| PHILADELPHIA, PA. | 401 North Broad Street, Bell-Walnut 2-6997 |
| REDWOOD CITY, CALIF. | Broadway and National, Emerson 6-3861 |
| WEST SPRINGFIELD, MASS. | 1025 Elm Street, Springfield 2-1881 |
| EAST SYRACUSE, N. Y. | 226 Roby Avenue, East Syracuse 366 |
| WICHITA, KANSAS | 340 North St. Francis Ave., Wichita 2-6971 |


"O" RINGS
OIL SEALS

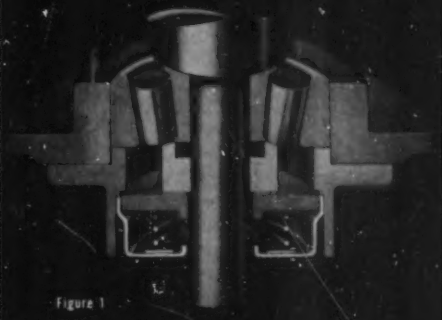


Figure 1

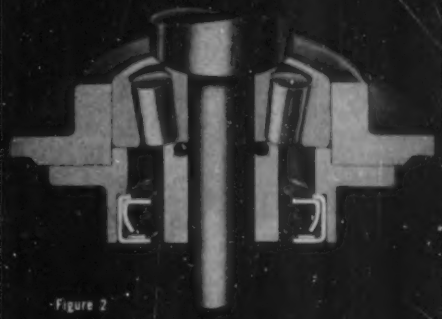
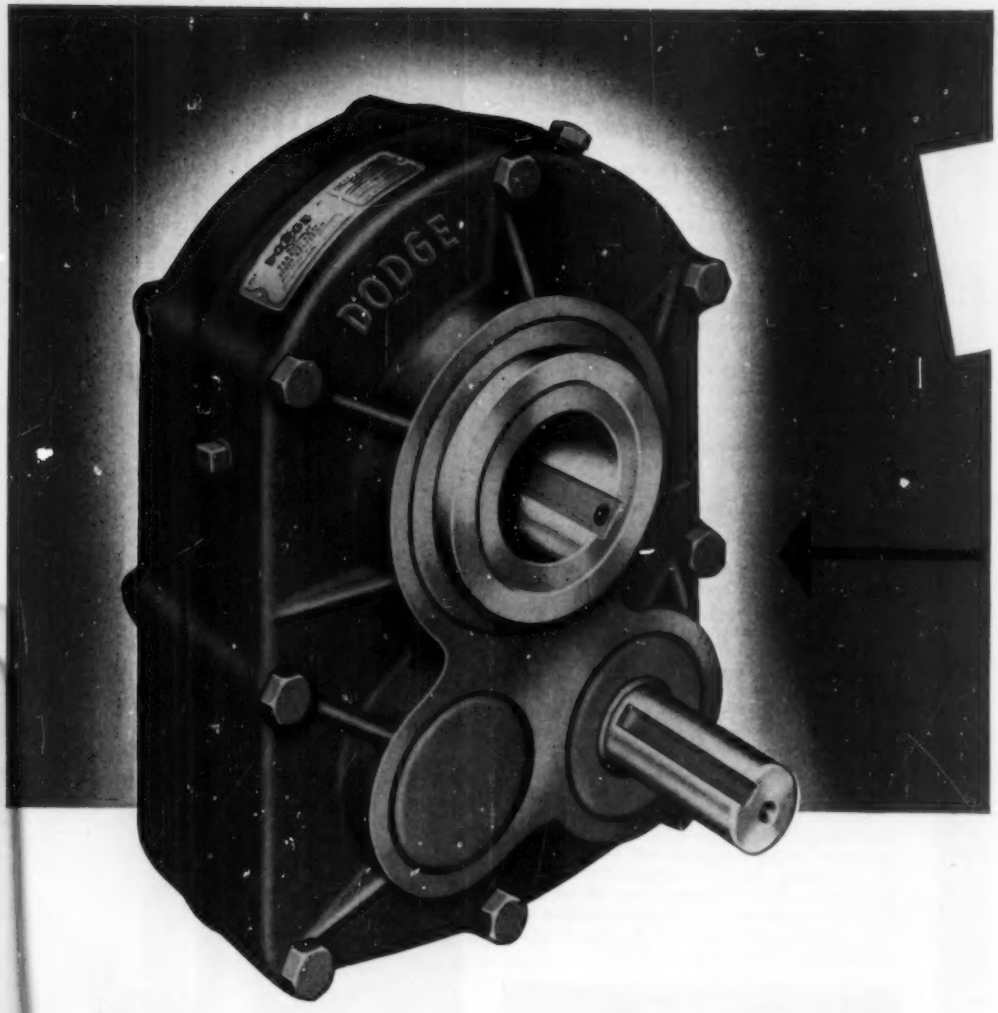


Figure 2

NATIONAL
OIL AND FLUID SEALS




- Available from *stock*, with stock-product economy. Built in six sizes with capacities up to 25 H.P. Develops any output speed from 13 to 133 R.P.M. through the use of stock TAPER-LOCK sheaves as prescribed for the job.
- No special engineering required. No foundation to provide. No flexible couplings. No sliding base. No "lining-up" difficulties. No expensive installation.
- Reducer locks on the shaft-to-be-driven with a steel locking collar on *each side* of unit.
- Unit is driven through any V-Belt Drive. This absorbs shock loads. Speeds can be varied by simple change of sheave. Interchangeable bushings adapt shaft sleeve to different shaft sizes, making application to other machines practical and easy.
- Torque arm, fastened to floor or any fixed object, anchors the reducer unit. Turnbuckle in torque arm provides fast and accurate adjustment of belt tension.
- Extremely compact, light. (Size No. 1 weighs only 38 pounds.) Extremely rugged. Cast iron housing. Double reduction train of helical steel gears. Shaved for *quiet* operation—heat treated for *long* life. Generous capacity deep groove ball bearings. Neoprene seals.
- Backstop available when required. Simple and positive. Easily installed on input shaft. Sealed from dust and dirt inside the reducer case.
- The TORQUE-ARM SPEED REDUCER is a *DODGE* product—which means *fine* engineering, *quality* manufacture. Get all the facts. ***WRITE*** for bulletin with selection tables.

# NEW!

# TORQUE-ARM SPEED REDUCER

## SAVES MONEY!

The Dodge TORQUE-ARM SPEED REDUCER is a new tool for the mechanical transmission of power, so practical in design, so effective in operation, so low in cost, that it promises to benefit industry as extensively as the famous Dodge-Timken Bearing, the Dodge Rolling Grip Clutch, the Dodge Taper-Lock Sheave and other Dodge "firsts."

If you use conveyors of any kind, bucket elevators, agitators, mixers, feeders, processors or similar machinery—here is your opportunity to improve your drives, reduce maintenance and make substantial savings on equipment and installation.

See your local Dodge Distributor. Simply give him your horsepower requirement and the desired speed and size of the shaft to be driven. He will furnish you *from stock* this complete speed reducer package, to fit your job accurately, economically.

**WRITE** to us for Bulletin No. A470 with details, specifications and easy-to-use selection tables.

**DODGE MANUFACTURING CORPORATION • 1200 UNION STREET, MISHAWAKA, INDIANA**

*CALL THE TRANSMISSIONEER*, your local Dodge Distributor, for information on new ways to improve machine performance, cut costs. Look for his name under "Power Transmission Equipment" in your classified telephone book.

# DODGE

of Mishawaka, Ind.

**FIRST IN POWER TRANSMISSION MACHINERY**

# a NEW STAINLESS STEEL has been invented by *Carpenter*...

This new Chrome-Nickel Stainless can do things that the 18-8's can't do. Invented in Carpenter's laboratories, it is an austenitic steel *with an extremely slow rate of work-hardening.*

We call the new steel *Carpenter Stainless No. 10.* Its slow rate of work-hardening eliminates fabricating problems often encountered with the 18-8 grades of Stainless. The development of No. 10 makes practical for the first time the economical production of many kinds of Chrome-Nickel Stainless parts, such as recessed head screws and upset nuts.

Carpenter Stainless No. 10 can be cold worked much easier than Type 302 Stainless. Its corrosion resistance is equal to and in some cases better than the 18-8 types.



A technical bulletin describing Carpenter Stainless No. 10 will be mailed if you will drop us a line on your company letterhead. The bulletin will help you get to know this new Stainless, recently invented in Carpenter's laboratories.

Another *Carpenter* First!

Economical production of many Chrome-Nickel headed parts has been made possible by Carpenter's invention of a new Stainless Steel that has a very slow rate of work-hardening.

**THE CARPENTER STEEL COMPANY, 117 W. Bern Street, Reading, Pa.**
Export Department: 233 Broadway, New York 7, N. Y. "CARSTEELCO"

*Carpenter*

more than corrosion resistance

## STAINLESS NO. 10

(Patent Pending)

FOR COLD HEADED AND UPSET PARTS

Type Analysis: Carbon ... 0.08% max. Chromium ... 16.00% Nickel ... 18.00%

Vari-Pitch

# AUTOMATIC SHEAVES

**WILLIAMS TOOL COMPANY, Brantford, Ontario, Canada selects Texrope Automatic Sheave for Pipe Threading Machines!**

# Give Efficient, Accurate Machine Tool Speeds!

HERE'S ANOTHER EXAMPLE of the versatility of *Texrope* Automatic Sheaves! Instantly *stepless* speed variations were required on these pipe threading machines to match the diameter and type of material being threaded.

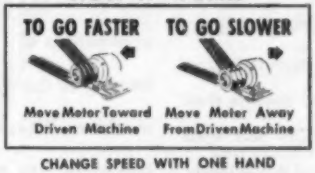
After considering many other means, Williams Tool Company installed a 2-groove R Section Vari-Pitch Automatic Sheave with 5.25 in. to 10.0 in. pitch diameter and a 7.2 in. pd companion sheave with clutch built into the hub.

This combination, plus a four-speed transmission gives them stepless speeds of 5.95 rpm to 34.7 rpm. And, because of the small size of the drive, it mounts in the small available space without change in machine design!

## GET BROAD APPLICATION

Vari-Pitch Automatic sheaves can replace almost any standard sheave on drives from 1½ to 40 hp (special to 60 hp) . . . will give you *stepless* speed changes in a matter of seconds . . . overall speed ratios of as high as 2 to 1.

## HOW IT WORKS




**CHANGE SPEED WITH ONE HAND WHILE MOTOR IS RUNNING**

For complete information on diameters and number of grooves, send coupon or check with your nearest A-C Sales Office or Authorized Dealer.

## MAIL COUPON FOR HELPFUL LITERATURE:

**ALLIS-CHALMERS, 1002A SO. 70 ST. MILWAUKEE, WIS.**

Please send me the literature checked below:

- ☐ 1. *Vari-Pitch* Automatic Sheaves — Section 20-P-50 (Part 4)
- ☐ 2. Handy Guide for Quick Selection of standard *Texrope* Drives — Bulletin (20B6051)

Name .....

Title .....

Firm .....

Address .....

City ..... State .....

A-2970

*Vari-Pitch* and *Texrope* are Allis-Chalmers trademarks.

**ALLIS-CHALMERS**

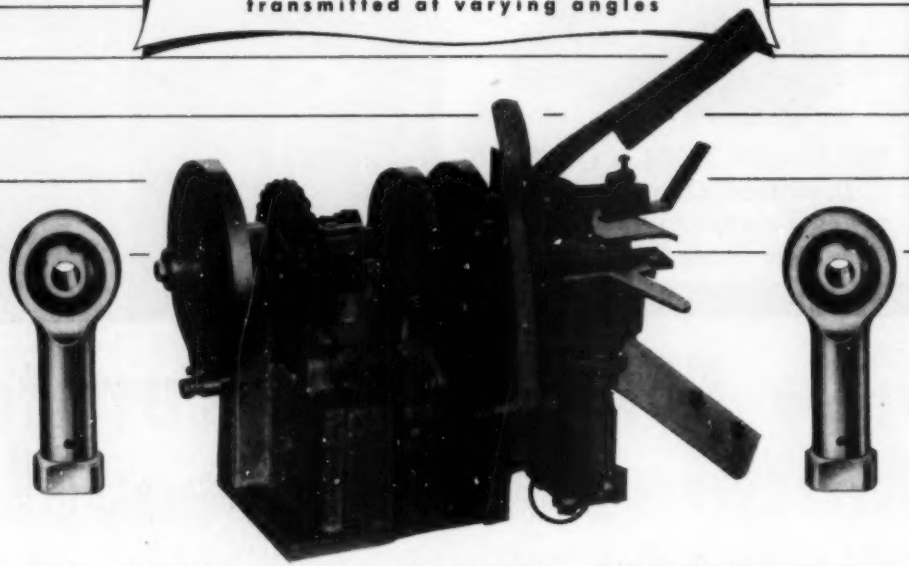
**ORIGINATORS OF THE MULTIPLE V-BELT DRIVE FOR INDUSTRY**

# HEIM

## *"Unibal"*

## SPHERICAL BEARINGS AND ROD ENDS

**Used wherever motion is to be transmitted at varying angles**



**ST. REGIS PAPER COMANY, OSWEGO, N.Y.**

**No. B-3146 VALVER HEAD**

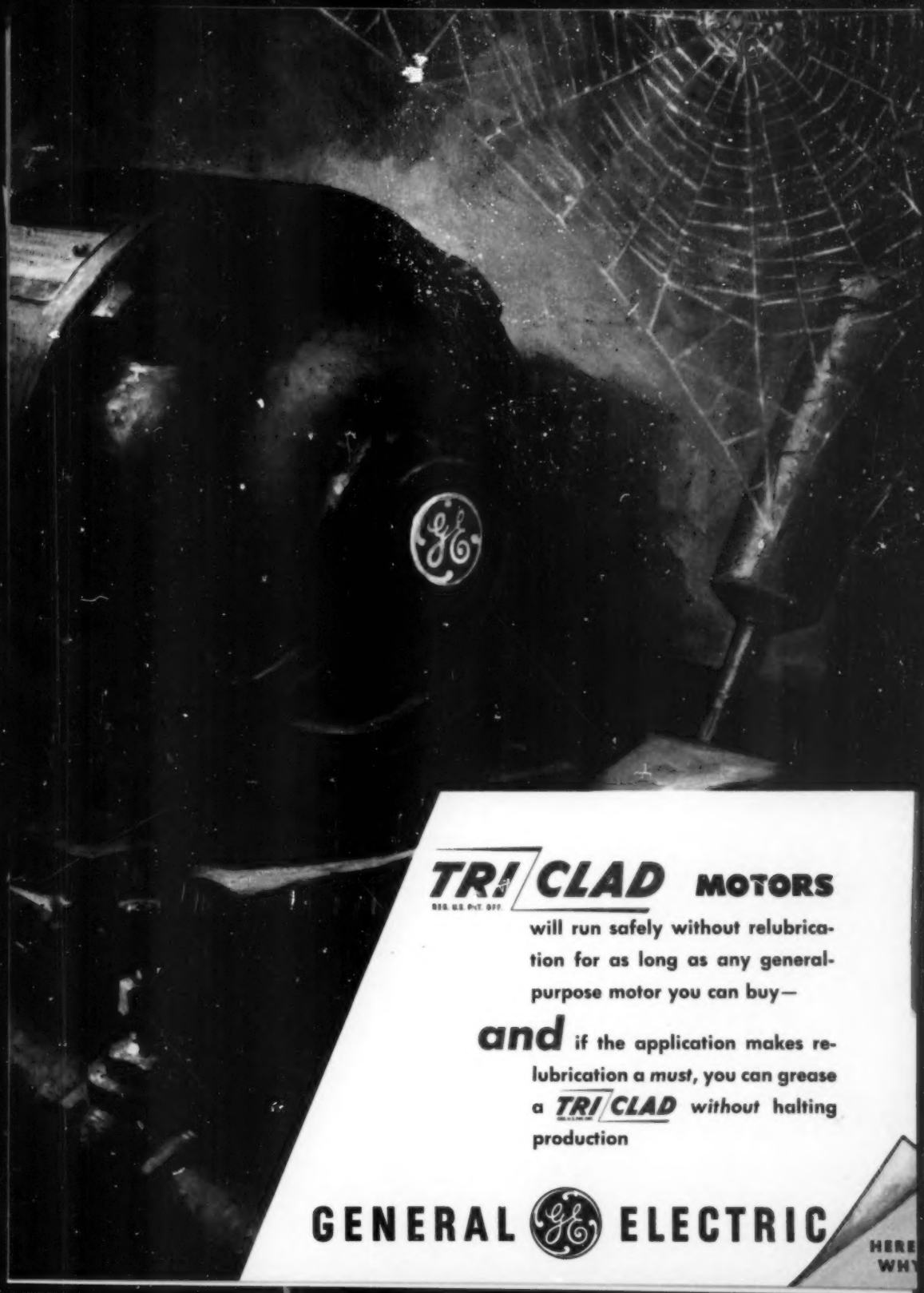
Like so many other American manufacturers whose products are leaders in their fields, the St. Regis Paper Co. has chosen HEIM "Unibal" SPHERICAL BEARING ROD ENDS to improve the smoother functioning of their machines. Illustrated here is their Valver Head machine with the HEIM rod ends circled. They carry maximum axial and thrust loads, and are self-aligning.

The Engineering Department of The Heim Co. will be pleased to work with you in suggesting possible applications of either the Heim "Unibal" Spherical Bearing or the Spherical Bearing Rod End to your machines. Whenever you think of transmitting motion at varying angles, think of HEIM. There is a size and male or female style to meet your needs.

*Complete catalogs are available upon request.*

**THE HEIM COMPANY**

**FAIRFIELD CONNECTICUT**


TRI CLAD MOTORS
REG. U.S. PAT. OFF.
will run safely without relubrication for as long as any general-purpose motor you can buy—
and if the application makes relubrication a must, you can grease a TRI CLAD without halting production
GENERAL ELECTRIC
HERE
WH

## TRI CLAD MOTORS will run safely without relubrication for as long as any general-purpose motor you can buy—

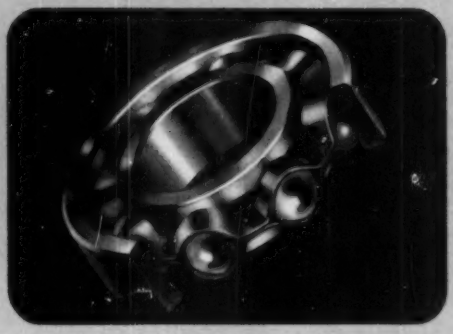
Tri-Clad extra lubrication "protection" can save you money because:

**1.** Tri-Clad's oversize grease reservoir and the heaviest standard-service bearings mean you do not have to bother with greasing between motor check-ups.

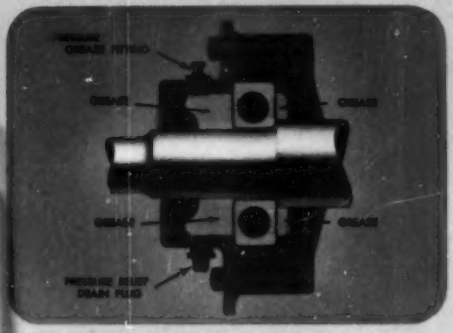
**2.** When relubrication is needed on those tough applications, you can grease a Tri-Clad without interrupting production-line operations.

Tri-Clads are grease-gun easy to lubricate *on the job*. Moreover, a Tri-Clad motor will run safely where an ordinary motor would fail. Chances are you'll be spared the cost of a "special" motor.

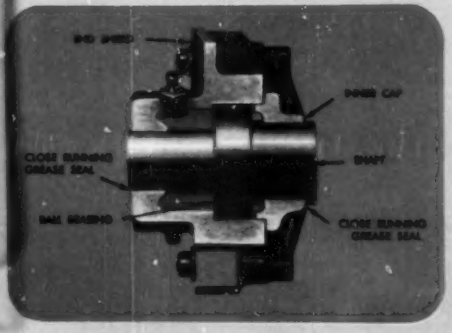
**YOU BE THE JUDGE!** The best way to prove to yourself that Tri-Clad gives you the most for your motor dollar is to contact your local G-E office. Tri-Clad stocks are complete. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*



**1** **EXTRA BEARING PROTECTION** — Tri-Clad gives you extra bearing protection because heaviest standard-service bearings are carefully selected to withstand severe loads for long periods.




**2** **EXTRA GREASE** — Four times the ordinary amount of grease is packed into the large Tri-Clad grease reservoir. Since bearing life depends on grease, this means that Tri-Clad motors will run safely for years — for as long as any general-purpose motor you can buy.




**3** **SEALED-IN BEARINGS** — Bearings and grease are completely sealed in a cast housing with long running seals for extra protection from dirt, dust, and lubricant leakage.

**4** **PRESSURE-RELIEF GREASING** — An efficient system of pressure-relief lubrication (with standard fittings) enables a Tri-Clad motor to be quickly and easily greased on the job when and if it's needed.

GENERAL ELECTRIC

# MAGNETOSTRICTION

***Once a laboratory curiosity...now serving science in surprising ways...with the help of*** NICKEL

Like Hertzian waves, Roentgen rays, and radioactivity . . . magnetostriction was once just a physicist's plaything.

Early experimenters noted with interest the unusual behavior of magnetized ferromagnetic materials . . . the "spontaneous" dimensional changes; and inversely, the permeability changes when dimensions were forcibly altered.

But as magnetostriction developed from laboratory demonstration to practical application, it was discovered that few materials offered sufficiently high magnetostrictive response. When the essentials of economy, workability, and availability were considered, the number of suitable materials was still more limited.

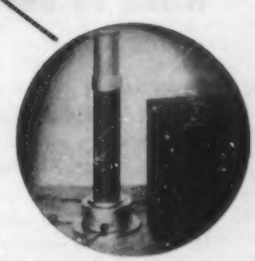
• • •

Both research and practice have now established Nickel as a satisfactory solution to this problem. Nickel's magnetostrictive contraction of approximately thirty parts per million is exceeded only by a few costly special alloys.

Nickel offers, in addition, excellent corrosion resistance, good resistance to the destructive effects of extreme temperatures, plus strength and hardness equal or superior to that of low-carbon steel. For special applications, even greater hardness can be obtained in Permanickel* through heat treatment, with only a small loss in mechano-magnetic characteristics.

If you are interested in magnetostrictive oscillators . . . either for manufacture or application . . . Inco's Technical Service Department will gladly put at your disposal data accumulated from both research and practice.

For your reference files, write for: "*Magnetostriction*", and "*66 Practical Ideas for Metal Problems in Electrical Products.*"



**Bacteria Killer.** A 9 Kc magnetostrictive oscillator used for sterilization in the chemical and pharmaceutical industries. The magnetostrictive material is laminated Nickel. Made by Raytheon Manufacturing Co., Waltham, Mass.

**Phonograph Pick-Up:** The magnetostrictive unit in this device is a 20-mil Nickel wire which is stretched between the poles of a horseshoe magnet. Variations in torsion caused by deflections of the needle produce flux variations in two pick-up coils that are wound around the stretched Nickel wire.

**A FEW OF MANY APPLICATIONS FOR MAGNETOSTRICTIVE EQUIPMENT**

- **"Sonar" and related devices for detecting submarines and ships.**
- **The "Fathometer", for determining depth of waters; locating schools of fish.**
- **Electrical filters, such as band pass filters for radio receiving sets.**
- **Homogenization and sterilization of milk.**
- **Acceleration of chemical reactions and cavitation effects.**
- **Strain gages.**
- **Vibration and engine detonation.**
- **Phonograph pick-ups.**
- **Frequency control of oscillators operating below 100 Kc.**
- **Dust and smoke precipitation.**

EMBLEM OF SERVICE

**NICKEL** INCO **ALLOYS**

**Monel* • "K"* Monel • "R"* Monel • "KR"* Monel • Nickel • "D"* Nickel • "L"* Nickel Duranickel* • Permanickel* Inconel* • Inconel "X"***

**THE INTERNATIONAL NICKEL COMPANY, INC.**

***67 Wall Street, New York 5, N.Y.***

*Reg. U. S. Pat. Off.

## WHEN TO USE XLS BALL BEARINGS

Wherever savings in space and weight must be engineered into your design without sacrificing thrust and radial load capacity, Federal XLS Ball Bearings may hold the answer to your problem.

Light and compact, with uninterrupted deep groove races, the XLS series is produced with 1⅛" to 10" bores and outside diameters from 2⅜" to 13¼". Cross section area through any pair of races may range from 68% to 33⅓% of the area of corresponding metric size bearings.

**These design features are adaptable for compact clutches;** in thin-walled housings; for large diameter shafts where load is such that extremely high carrying capacity is not required of the bearing; in instrument or actuator design; in fact wherever available bearing space is at a premium and weight saving of prime importance.

**Our Catalog "K" describes the XLS series** as well as the complete Federal Ball Bearing line...every type and size, shielded and sealed...for every anti-friction need. (A few of the many series are shown here.) You'll also find ball bearing selection charts among the 100 pages of engineering data to help you compute bearing loads, determine capacities at every speed, and select the type and size bearing best suited to your application. Write for this 260-page catalog today.

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, NEW YORK

*Makers of Fine Ball Bearings*

Quality since 1908

# FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

# 2+2=99,999,999!

YES, 2 plus 2 *can* equal 99,999,999, if a vital spring fails in an adding or computing machine. And a broken spring can cause much more subtle errors which are hard to detect. The machine may operate correctly for weeks, then suddenly insert small (or large) errors which will completely upset an involved operation.

To guard against these plaguing failures, many manufacturers of computing equipment use the very best spring wire available today—U·S·S Amerspring Music Wire.

Amerspring is tough . . . *really* tough. And since it has outstanding resistance to fatigue, springs made of this high quality music wire can withstand the continual vibration and shock present in many types of calculating machines. Also, Amerspring has the high tensile strength, resiliency, uniformity and freedom from defects that are essential for top performance of small precision springs.

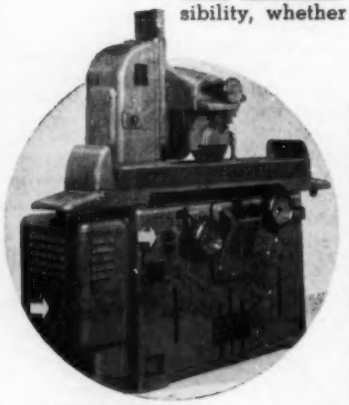
For more information, contact our nearest field office.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM, SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

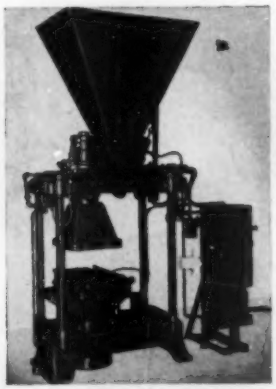
UNITED STATES STEEL

# DESIGN LEADERSHIP

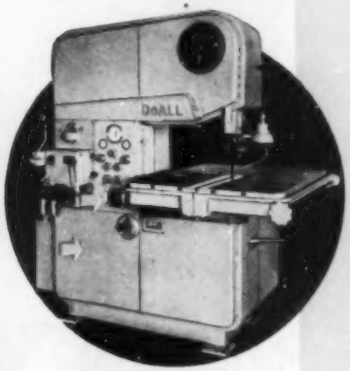
**Square D has the right electric motor control for virtually any A.C. or D.C. application.** (These pictures show only a small sample of the many kinds of equipment for which Square D control is being used throughout all industry.) The reasons—completeness of line and basic designing of all standard devices for compactness and accessibility, whether used individually or wired into control panels.



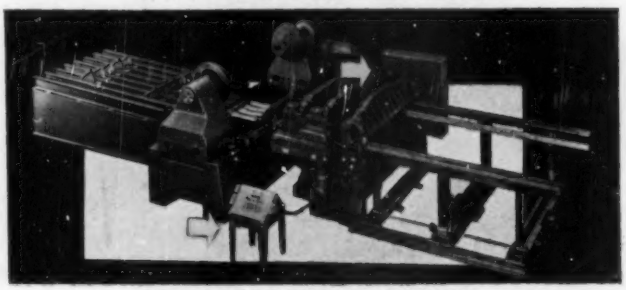
**SMALL GRINDER**
Thompson Grinder Company



**CORE BLOWING MACHINE**
International Molding Machine Company




**BAND MACHINE TOOL**
DoALL Company



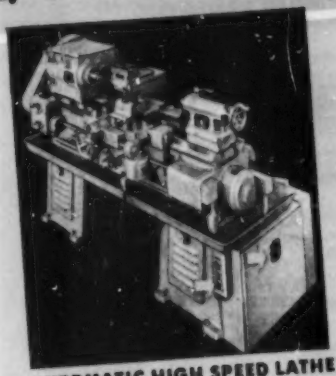
**AUTOMATIC SHEARING MACHINE**
Cleveland Punch & Shear Works Company

**SQUARE D COMPANY**

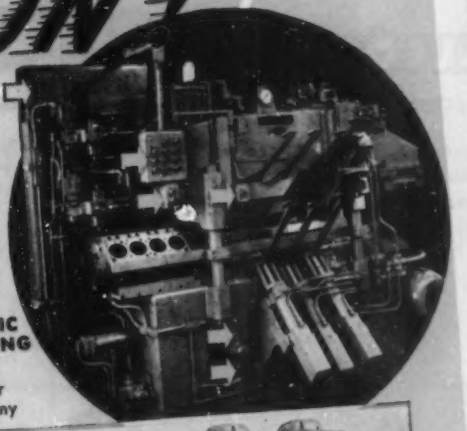
DETROIT · MILWAUKEE · LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

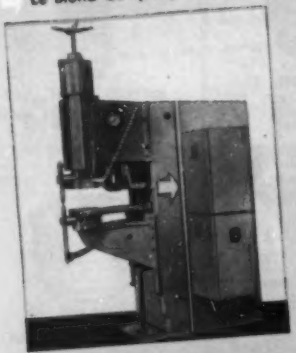
# IN ACTION!



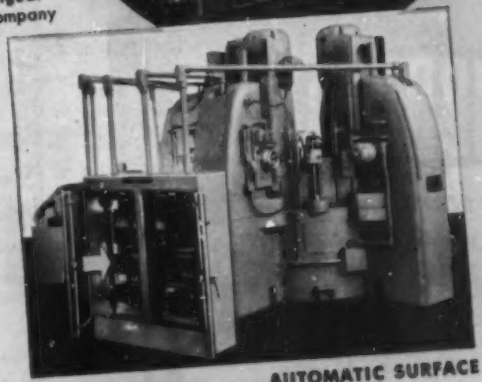
**AUTOMATIC HIGH SPEED LATHE**
Le Blond Company



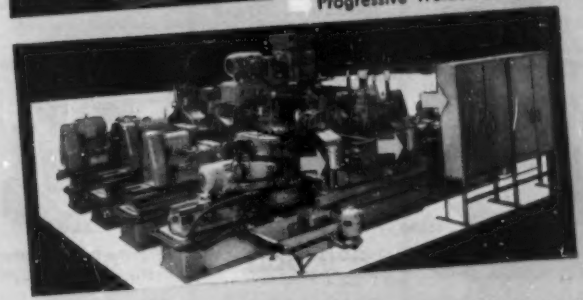
**HYDRAULIC ASSEMBLING PRESS**
Oilgear Company



**RESISTANCE WELDING MACHINE**
Progressive Welder Company



**AUTOMATIC SURFACE GRINDER**
Blanchard Machine Company



**AUTOMATIC BORING MACHINE**
W. F. and John Barnes Company

*Write* for Machine Tool Control Bulletin 207.
It details Square D's complete line.
Address Square D Company, 4041 N. Richards St., Milwaukee 12, Wisconsin.

## HALLOWELL

***SHOP EQUIPMENT OF STEEL***

*Ready-made*, standardized, interchangeable units. Sturdy, welded construction lasts longer, minimizes maintenance.

WORK BENCH OF STEEL. Steel or laminated wood top.

CARRY-TOOL, the handier tool stand.

STEEL STOOL. Strong, welded construction.

FOREMAN'S DESK OF STEEL

STEEL POSTURE STOOL with adjustable back.

## UNBRAKO

***SOCKET SCREW PRODUCTS***

*Knurled*, slip-proof cap screw heads speed assembly. *Knurled* points make set screws self-locking . . . "they won't shake loose!" Advanced manufacturing methods make UNBRAKOS stronger, tougher, more reliable.

KNURLED HEAD SOCKET CAP SCREW

KNURLED POINT, *SELF-LOCKING* SOCKET SET SCREW

KNURLED POINT, *SELF-LOCKING* SQUARE HEAD SET SCREW

KNURLED HEAD SOCKET STRIPPER BOLT

FLAT HEAD SOCKET CAP SCREW

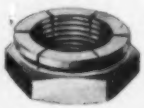
DRYSEAL PRESSURE PLUG

## FLEXLOC

***SELF-LOCKING NUTS***

One-piece, all-metal, for maximum strength—minimum trouble. Positive, *automatic* locking. FLEXLOCS serve as both *stop* and *lock-nuts*. "Positively won't shake loose."

*SELF-LOCKING* STOP NUT, REGULAR HEIGHT



*SELF-LOCKING* STOP NUT, "THIN"

EXTERNAL WRENCHING, *SELF-LOCKING* STOP NUT

See us at Space 128, A. S. T. E. Exposition, April 10-14, Convention Hall, Philadelphia

# SPS

## STANDARD PRESSED STEEL CO.

*JENKINTOWN 28, PENNSYLVANIA*

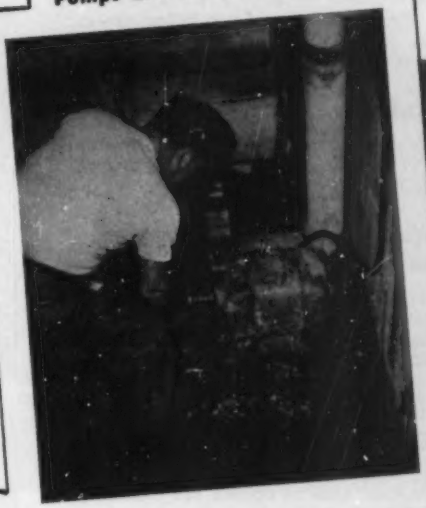
YOU CAN BE **SURE**.. IF IT'S

Westinghouse

Pumps and Compressors

## Submerged in 6 ft. of Water..Open Motor Pumps Sump Dry

When water rose accidentally in a sump of an eastern plant, an open Life-Line motor was covered by six feet of water. Someone pressed the starter, and the Life-Line pumped the sump dry. Outside of being covered with a thick coating of mud and [illegible] motor [illegible]



# Can your pumps use *MOTOR STAMINA* like this?

We certainly do not recommend open motors be operated under these conditions—in fact, we say DON'T DO IT! But this actual example illustrates the real stamina built into Life-Line motors—stamina resulting from improved materials and manufacturing methods.

Take the stator, for example. Coils are wound of Tufvar wire—wire you can pound with a sledge, tie into knots, without disturbing the insulation. Pear-shaped slots enable coils to be slipped into place without forcing. A fiber wedge closes top of slot, seals against dirt and moisture. Multiple dips and bakes in Thermoset varnish give the stator a tough flexible film, resistant to oil, moisture, acid and alkali. That's why, in the above example, there was no winding short-out—even under water.

It costs no more to get this extra motor stamina. Simply specify Life-Line as the drive for your equipment. Ask your local Westinghouse representative for details and a copy of booklet B-3842, or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.

J-21576

*If you figure LIFE-COSTS . . . you'll figure LIFE-LINE*

Westinghouse *Life-Line* Motors

INDUSTRY'S LEADING MOTOR

### Keep Bolted Assemblies Tighter Longer

The reactive pressure of Reliance Spring Lock Washers automatically compensates for dimensional changes in bolted assemblies produced by wear, vibration and bolt stretch.

### Maximum Reactive Pressure

Reliance Spring Lock Washers operate like a powerful helical coil spring to keep bolts *tighter longer.*

### Dependable, Non-Fatiguing Reactive Force

Reliance Spring Lock Washers are compensating devices made of cold drawn spring steel to give them inherent reactive pressure over a wide reactive range.

### Full Nut-Thread Engagement —Thrust Bearing Feature

Reliance Spring Lock Washers permit use of regular nuts to tighten the assembly and do not rely on single thread engagement. The Spring Lock Washer acts as a hardened thrust bearing in the tightening operation. It is free to rotate, allowing a greater torque in tightening the assembly.

### Cannot Injure Bolt Threads

Reliance Spring Lock Washers do not make contact with bolt threads. Reactive pressure is transferred to the bolt through contact the threads of the nut make with those of the bolt.

### Simple, Compact

Reliance Spring Lock Washers are the simplest of all locking-compensating devices. They are compact and inexpensive.

### Can Be Used Anywhere — Quick And Easy To Use

Reliance Spring Lock Washers can be used under any type of nut or under the bolt head. To assemble with a Reliance Spring Lock Washer merely place the proper kind and size of Reliance Spring Lock Washer on the bolt and wrench the nut tight.

"Products Efficiently Engineered are Reliance Spring Lock Washer Equipped."

## in all respects the best insurance of dependable, enduring bolt tightness

For superior performance, Reliance Spring Lock Washers are made from selected cold drawn spring steel, processed to develop uniform, high, non-fatiguing reactive pressure.

Reliance Spring Lock Washers can also be furnished in stainless steel and non-ferrous metals.

EATON

EATON MANUFACTURING COMPANY

*Reliance* SPRING LOCK WASHERS

RELIANCE DIVISION
MASSILLON, OHIO

Sales Offices: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal

# GEAR SETS RATED TO YOUR JOB

## A MAJOR ADVANCE IN GEAR APPLICATION

### SPECIFIC APPLICATION OF DUTI-RATED GEARS

*In the analysis of a specific application, the Foote Bros.* **Duti-rated** *Gear Set of 60 Rockwell C Hardness made by the* **Duti-rated** *process method, was able to do the work of an accurate industrial gear set made to a heat-treated, hobbed and shaved construction in 64% of the center distance and 33% of the weight. This same gear set was able to do the work of a commercial grade gear set of heat-treated and hobbed construction in 46% of the center distance and 12% of the weight.*

Foote Bros. has now made available to designing engineers and equipment builders a new product—Standardized precision **Duti-rated** Gear Sets that may be as conveniently selected as antifriction bearings. Sizes range from 1 h. p. through 200 h.p. with a wide selection of ratios and center distances. **Duti-rated** Gears are available in helical sets (parallel shafts) and worm gears (right angle drives).

These gear sets may be directly applied to the solution of your gear problems with all the available factors of life, load and type of service taken into consideration. They are pre-engineered, produced under most exacting controls and pre-tested to meet your requirements.

**Duti-rated** Gears offer new advances in gear production achieved through improved design, new manufacturing processes, the most advanced standard and special facilities, and better control of methods and heat-treatment. **Duti-rated** Gears represent a new conception in gear accuracy and precision. File hard tooth surfaces and tough, resilient cores give more load carrying capacity—longer wear life.

**Duti-rated** Gears bring you these advantages:

Simplified and dependable gear selection.
Cost saving of from 10% to 50% or more.
Standards of accuracy never before commercially available.
High mechanical efficiency.
Important space and weight savings in gears and related parts.
Quiet operation.
Quickly available.

Every engineer and every builder of equipment should learn more about this advanced method of gear selection and application. Mail the coupon for engineering manual DRA today.

FOOTE BROS.

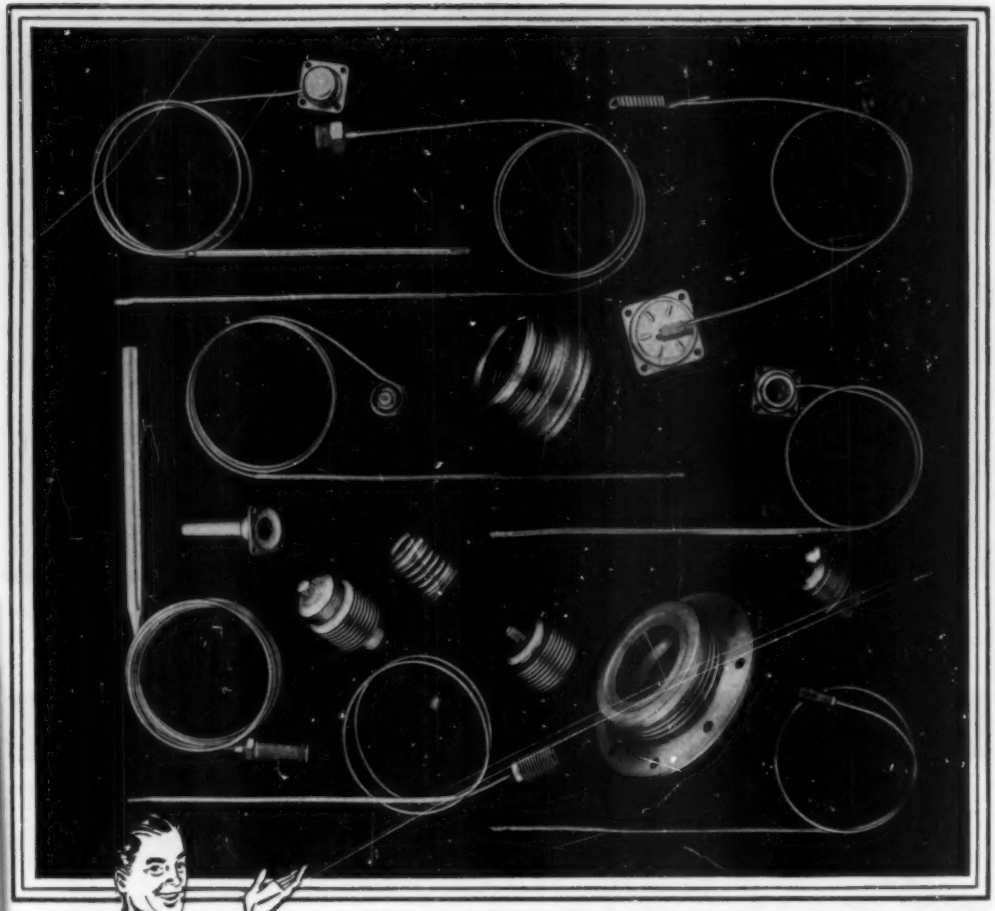
*Better Power Transmission Through Better Gears*

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 South Western Blvd., Chicago 9, Illinois

Foote Bros. Gear and Machine Corporation
Dept. W, 4545 S. Western Boulevard
Chicago 9, Illinois

I am interested in the application of standardized **Duti-rated** Gear Sets. Please send me Engineering Manual DRA.

*Name*.....
*Company*.....
*Position*.....
*Address*.....
*City*..... *State*.....



*Each of these*

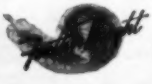
**BELLOWS ASSEMBLIES** *was a different problem. How different is yours?*

If you merely suspect that a bellows assembly can do your job, you're in the same position where some of our most satisfied customers started. Our engineering department will be glad to analyze *your* problem, too. Send *your* sketches and specifications for confidential study and recommendations. There is no obligation.

CLIFFORD MANUFACTURING COMPANY, 122 Grove Street, Waltham 54, Massachusetts. *Division of Standard-Thomson Corporation.* Offices in New York, Detroit, Chicago and Los Angeles.

*First with the Facts on Hydraulically-Formed Bellows*

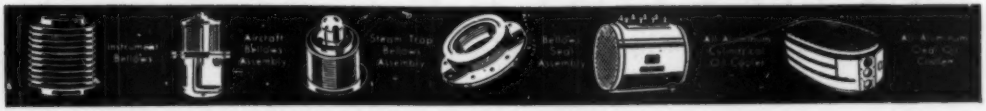
**CLIFFORD**



ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

HYDRON Metal Bellows



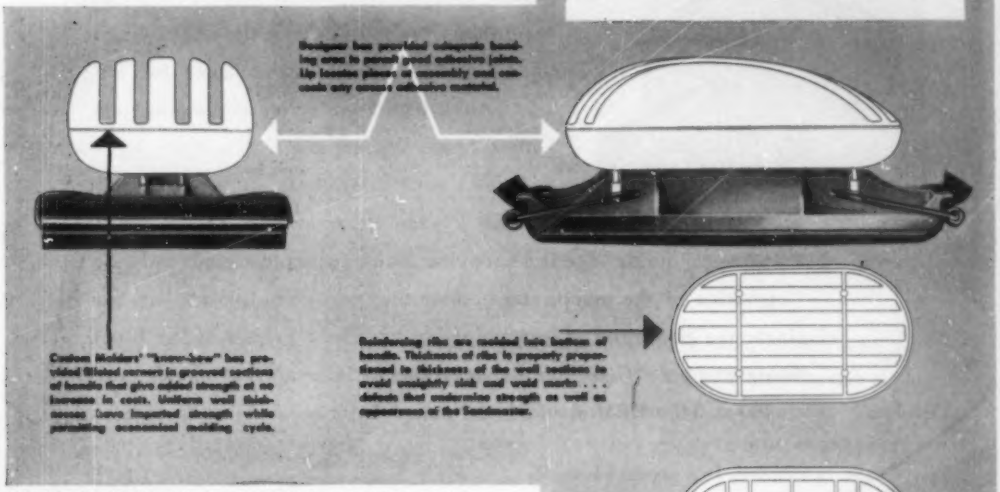
*"designed right—in the right plastic"*

# CUSTOM MOLDERS' KNOW-HOW plus STYRON

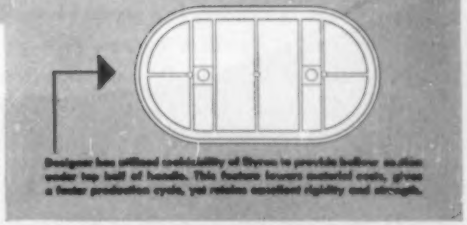
## *solves another production problem!*

**ANOTHER CUSTOM MOLDING CASE HISTORY**

Styron was specified by the Custom Molder for the handle of this Red Top Sandmaster. Styron was selected because it could withstand the hard usage received by this product and meant lower material cost and faster assembly, and virtual elimination of finishing operations.


Designer has provided adequate bonding area to permit good adhesive joints. Lip locates pieces at assembly and conceals any excess adhesive material.
Custom Molders' "know-how" has provided fillated corners in grooved sections of handle that give added strength at no increase in costs. Uniform wall thickness have imparted strength while permitting economical molding cycle.
Reinforcing ribs are molded into bottom of handle. Thickness of ribs is properly proportioned to thickness of the wall sections to avoid unsightly sink and weld marks . . . defects that undermine strength as well as appearance of the Sandmaster.

**Molded by United Plastics Industries, Vassar, Michigan, for Red Top Products, 7410 Woodward Ave., Detroit, Michigan.**


Designer has utilized moldability of Styron to provide hollow section under top half of handle. This feature lowers material costs, gives a faster production cycle, yet retains excellent rigidity and strength.

Extensive design and engineering facilities are maintained by the skilled Custom Molder to help you solve difficult fabrication problems in plastics.

Here's your opportunity to utilize the skill of competent technicians working with a wide range of Styron (Dow polystyrene) formulations to produce the most pieces possible per dollar spent.

The combination of Dow Research and the Custom Molders' designing "know-how" helps you to use to full advantage the excellent properties of Dow Plastics in your products. Write Dow today and let us put you in touch with a qualified Custom Molder, who will help you solve your fabrication problem.

*Plastics Division—Dept. SOT-14*

**THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN**

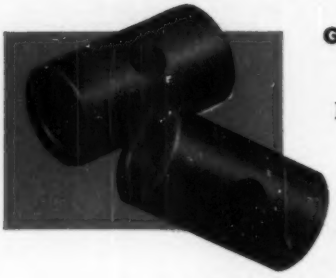
DOW plastics

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit • Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle • Dow Chemical of Canada, Limited, Toronto, Canada

# GRAPHITAR BEARINGS

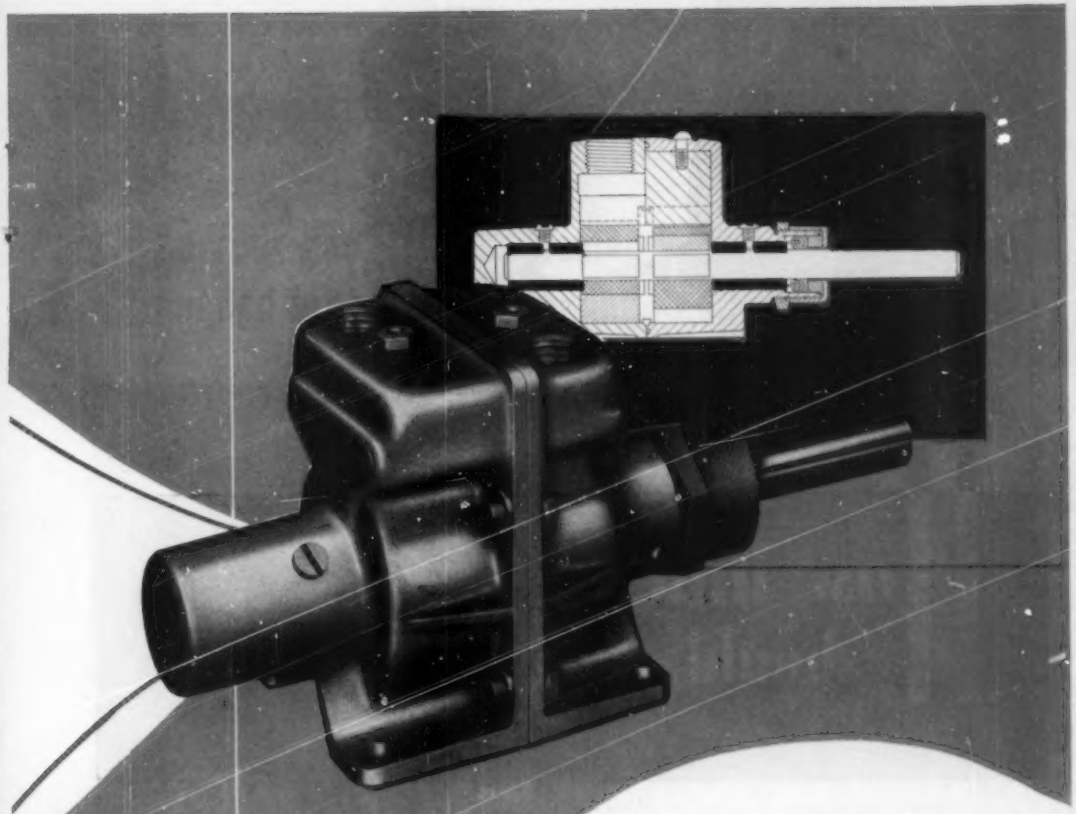
CARBON-GRAPHITE

## keep ECO gearless pump operating without lubrication



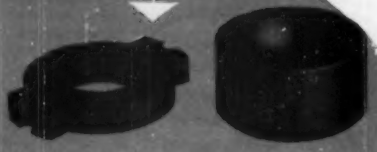
**Graphitar** bearings installed at both ends of the main pump shaft are helping the ECO Gearless Pump to operate without maintenance for long periods of time in scores of pumping jobs. ECO Gearless Pumps are designed for operation with gasoline or electric motors to handle a wide range of liquids and viscous fluids. The two Graphitar Bearings permit smooth and quiet operation of the pump, and because they require no lubrication, they eliminate the possibility of contamination by oils or greases of the liquid being pumped. Graphitar bearings operate efficiently at speeds from 300 to 3400 RPM at which the pump shafts are designed to operate.

THE UNITED STATES GRAPHITE COMPANY

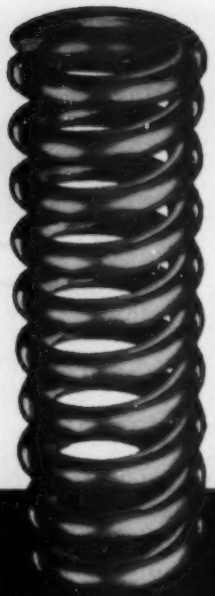


**Graphitar** has helped scores of manufacturers solve an otherwise difficult manufacturing problem because of its many unique and valuable characteristics. Graphitar is extremely light-weight — lighter than magnesium — yet it is mechanically strong and resistant to wear. Graphitar is chemically inert and unaffected by temperature extremes. It is ideal for seals, rings, pistons, bearings and bushings — it can be produced in any practical size and shape with tolerances as close as .0005" in small sizes. An inquiry or a sketch of your product will give our engineers an opportunity to show you where Graphitar parts may improve mechanical performance and save you money. We have a catalog which we will gladly send you.

**GRAPHITAR**



**DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN**

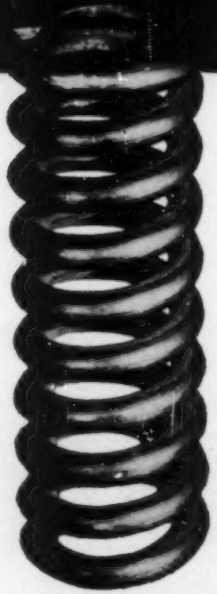


# How much should a spring cost?

● It all depends on the job it has to do. Because *overdesign* is just as bad as *underdesign*. You lose both ways—the end product either performs poorly, or it costs too much.

When costs are important, and they usually are, we don't believe in designing springs with unnecessary, elaborate and costly performance characteristics. We don't recommend stainless or high alloy steels if carbon steel will do the job. And we're quick to suggest ways to simplify springs—and cut their cost. You can be sure that, whenever it's possible, our designs will utilize the lowest cost material and fabrication methods that will do a good job for you.

Let our engineering staff—our comprehensive production and testing facilities go to work for you. You'll get a better spring—at a price—that will fit your needs *exactly*.



AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM, SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS **AMERICAN QUALITY SPRINGS**

UNITED STATES STEEL

# Correct gasket compression needed for effective sealing

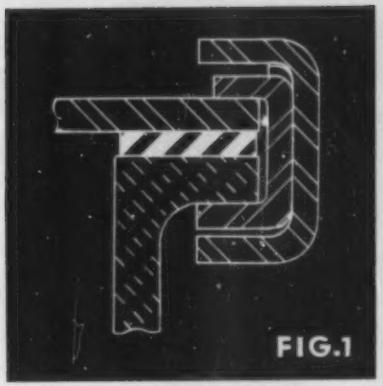


FIG.1

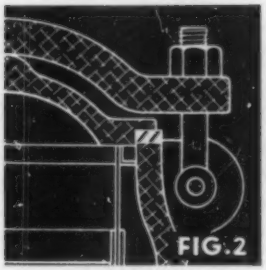


FIG.2

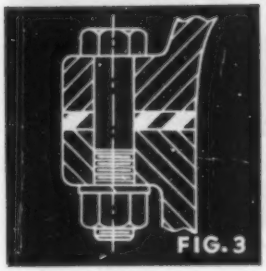


FIG.3

Resilient gaskets seal most effectively when correctly compressed. To insure correct compression, gasket compressibility should correspond to the flange pressure encountered in service. Otherwise, the gasket may be over-compressed and strained by excessive pressure or fail to seal properly because of insufficient pressure.

Correct compression can be achieved on many applications by using gaskets made from an Armstrong's Cork-and-Rubber Composition. Because cork-and-rubber is compounded of highly compressible cork particles and synthetic rubber of various durometer hardnesses, it offers a co-ordinated range of compressibilities capable of sealing effectively under widely varying flange pressures. Hence, choosing a cork-and-rubber material according to the application flange pressure eliminates faulty seals caused by incorrect compression.

Beside offering a wide range of compressibilities, cork-and-rubber provides exceptional resistance to most fluids and solvents. Depending on the substance being sealed, cork-and-rubber compositions made from Buna N, Neoprene, Thiokol, or other synthetic polymers are used.

Typical of the diverse sealing problems solved by cork-and-rubber are the three applications shown here.

In figure 1, a soft Cork-and-Neoprene material compresses 25% under 100 p.s.i. to make the glass cover of a watt-hour meter weather-tight.

A firm Cork-and-Thiokol composition was used to seal an aromatic fuel dispenser in figure 2. Here 500 p.s.i. produced 25% compression.

The 1500 p.s.i. bolt pressure available on the gate valve flange (figure 3) compressed a still firmer Cork-and-Neoprene material the recommended 25%.

Further information on correct gasket compression is available on pages 16 and 19 of the booklet offered below. Write for it today or call your Armstrong representative for further particulars.

## Send for this Gasket Handbook

You'll find useful application and specification data in the revised 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date information on straight synthetic rubber, cork-and-synthetic-rubber, and cork composition gasket and sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries.

For your free copy, fill in coupon at right and mail today.

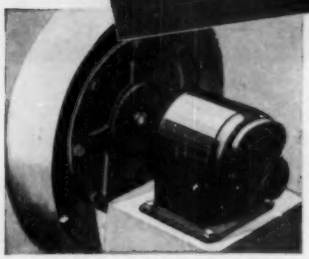
**ARMSTRONG CORK CO.**
Gaskets and Packings Dept.
7103 Arch Street, Lancaster, Pa.

Please send me at once a free copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

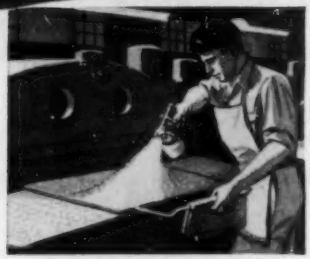
NAME.....
COMPANY.....
ADDRESS.....
CITY..... STATE.....

**ARMSTRONG'S**
GASKETS • PACKINGS • SEALS

# Which of these G-E SILICONE PRODUCTS can help your business?



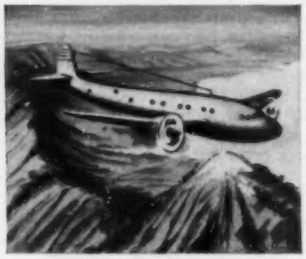
**General Electric silicone insulating resins** provide a new class of electrical insulation—particularly useful where equipment must operate at high temperatures or is subject to overloads.



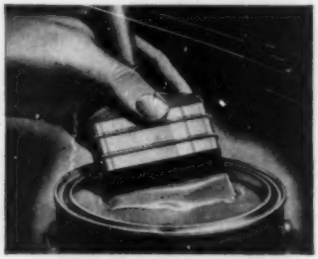
**General Electric silicone mold lubricants**—oils, greases and emulsions—help rubber molders and die-casters make better-looking products more easily, efficiently and economically.

**General Electric silicone rubber,** gum and compounds permit fabricators to make dozens of new and profitable items with characteristics unobtainable with other types of rubber.

**General Electric silicone anti-foam agents** reduce tendency to foaming in numerous processes and products—have many wide applications in the chemical and allied industries.



**General Electric silicone dielectric compounds** provide stable, waterproof seals for use in ignition systems, plastics insulators, electronic and many other kinds of equipment.



**General Electric silicone paint resins** offer manufacturers the opportunity to make paints, lacquers, and baking enamels with exceptional heat, weather and chemical resistance.

There's a place in almost every business for some General Electric silicone product. And almost every day some new way is found to apply the chemical inertness, temperature-resistance and flexibility of silicones.

Perhaps the examples above may suggest some use *you* can put them to. Like so many other manufacturers, you may find that these remarkable materials enable you to make different, better or more profitable products than ever before.

**To find out more about G-E silicones** and their place in *your* business, just write to Section F1, Chemical Department, General Electric Company, Pittsfield, Massachusetts.

GENERAL ELECTRIC

CD50-F1

SILICONES for Industry

# C/R *dependability costs you NOTHING*

Five thousand dollars for one oil seal! It isn't so startling to Chicago Rawhide engineers. Pilot oil seal models often cost that. And more. Research is costly. But C/R research saves money for you. It gives you the maximum of product dependability.

Since the days when Chicago Rawhide made the early automotive oil seals, C/R research has been applied to the solution of fluid retention and exclusion problems in every type of mechanism. This research has had just one aim: complete dependability under all circumstances. As a result, Chicago Rawhide has become the world's largest manufacturer of shaft-type oil seals. This C/R experience is important to you, because dependability can not be measured in ordinary specifications.

When you select C/R "Perfect" Oil Seals, you know they'll be right for the job. Each is specially engineered —correctly designed to assure dependable performance. C/R research helps you build a high degree of dependability in your own product. It costs you nothing.

***Chicago Rawhide engineering service is always available for the solution of your particular sealing problems.***

**CHICAGO RAWHIDE MANUFACTURING CO.**

1299 Elston Avenue **OIL SEAL DIVISION** Chicago 22, Illinois

Chicago Rawhide Manufacturing Company specializes in mechanical sealing and protective products: oil seals and special diaphragms, boots, gaskets, washers and packings of *Sirvene* synthetic rubber and *Sirvis* mechanical leather.

**ENGINEERS:** We will be pleased to send you engineering data on "Perfect" Oil Seals on receipt of your written request.

**PERFECT**
*Oil Seals*

**In any unique sealing or protection problems involving molded mechanical pliables . . .**

# X = SIRVENE

The "X" factor in any mechanism is the critical factor which determines success or failure. Often "X" is a pliable part, such as a diaphragm, boot, or gasket, which must meet a seemingly impossible combination of physical properties and resistance characteristics.

When you are faced with such conditions, consider Sirvene. Taking your specific performance requirements, Sirvene engineers will assist you in perfecting the design, then work out the proper combination of oil-resistant elastomers, do the developmental work and produce the parts in quantity under strict laboratory control. You can depend on uniform quality and micrometric accuracy in every part. When you have a difficult "X" factor problem involving flexible molded pliables for mechanical sealing or protection—call on Sirvene.

**CHICAGO RAWHIDE MANUFACTURING CO.**

1299 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois

Chicago Rawhide Manufacturing Company specializes in mechanical sealing and protective products: oil seals and special diaphragms, boots, gaskets, washers and packings of *Sirvene* synthetic rubber and *Sirvis* mechanical leather.

**ENGINEERS:** For basic information, write for your copy of "Engineering with Sirvene". There is no charge.

New York • Philadelphia • Detroit • Los Angeles • Cleveland • Boston • Pittsburgh • San Francisco • Cincinnati • Kansas City • Syracuse • Peoria • Minneapolis • Houston

**SIRVENE**

THE *SCIENTIFIC* COMPOUNDED ELASTOMER

# How to be right in the center of things

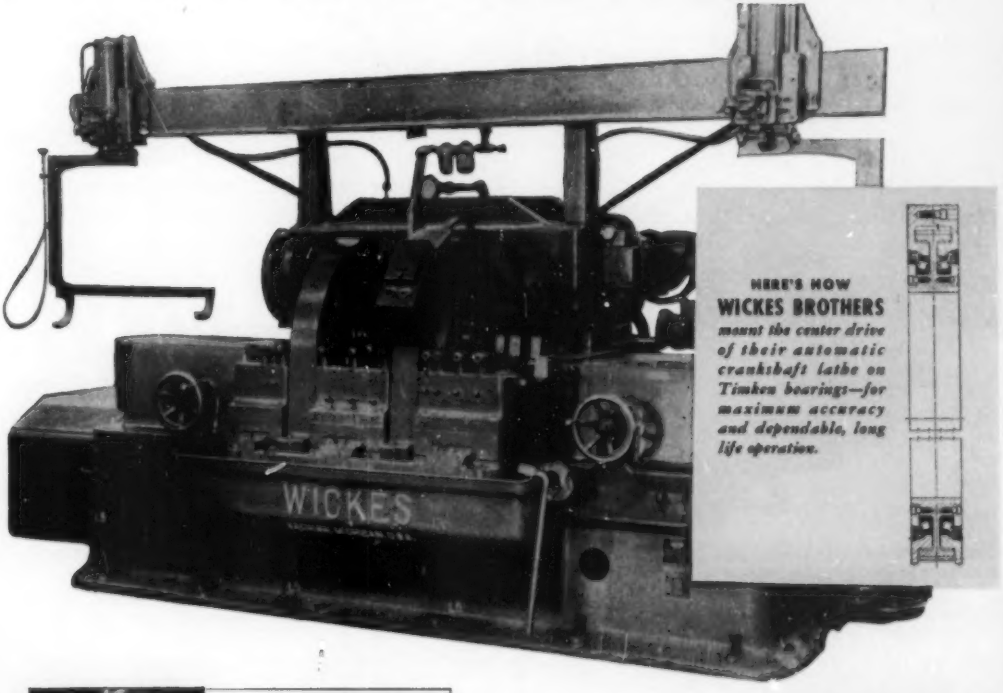
WITH a center drive crankshaft lathe like the one shown below, continued accuracy and high speed production depend largely on the big bearings in which the center chuck revolves. For maximum precision and dependable operation with minimum friction, Wickes Brothers mount the center drive on Timken® tapered roller bearings.

Due to the line contact between the rolls and races, Timken bearings have extra load-carrying capacity—give the center chuck maximum support. The work is held in proper position. The tapered construction of the bearings enables them to carry both radial and thrust loads—in any combination.

Timken bearings are precision products throughout. The rolls and races are made of Timken fine alloy steel for toughness, then case-hardened for exceptional resistance to wear. True rolling motion, and incredible smoothness of rolls and races results in virtually friction-free operation.

Over the years, the dependable performance and public acceptance of Timken bearings have made Timken-equipped products first choice throughout industry. Timken bearings help build greater preference for your product among customers. When you specify bearings, specify "Timken". And when buying new equipment, make sure it is Timken bearing equipped. Look for the trade-mark "Timken" on the bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

*This symbol on a product means its bearings are the best.*




**HERE'S HOW WICKES BROTHERS** *mount the center drive of their automatic crankshaft lathe on Timken bearings—for maximum accuracy and dependable, long life operation.*

**FINISHED TO CLOSER TOLERANCES**

Finishing to incredible smoothness accounts for much of the precise, smooth rolling performance of Timken bearings. This honing operation is typical of the amazingly accurate manufacturing methods at Timken.

The Timken Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

**TIMKEN**

TRADE MARK REG. U. S. PAT. OFF.

**TAPERED ROLLER BEARINGS**

NOT JUST A BALL ○ NOT JUST A ROLLER ⊃ THE TIMKEN TAPERED ROLLER ⊃ BEARING TAKES RADIAL ⫴ AND THRUST →⫴← LOADS OR ANY COMBINATION →✳←

# Light the Way to New Sales

## with VINYLITE BRAND Plastic Rigid Sheets

Lampshades courtesy
L. A. Goodman Mfg. Co.,
131 West 63rd Street, Chicago, Ill.

Seen these beautiful, multi-colored, washable lampshades in the stores? They are one of hundreds of brilliant new uses of VINYLITE Plastic Rigid Sheets. Easily formed and readily printed, they hold their shape indefinitely. These qualities plus fine styling have already zoomed the reasonably priced lampshades into mass sales.

VINYLITE Brand Plastic Rigid Sheets are waterproof, chemical resistant, and flameproof. They are available in an unlimited range of colors—either clear, translucent, or opaque, with glossy smooth or matte surfaces. These useful properties help make greatly improved doll faces, three-dimensional counter displays, calendar business cards, precision drafting instruments, Christmas tree ornaments, and many more useful items.

The exceptional versatility of VINYLITE Brand Plastics, in a variety of types and forms, can upgrade your products, too. Bring your problems to Bakelite engineers. With 40 years of plastics experience to draw upon, they'll surely be able to help. Write Dept. HS-10.

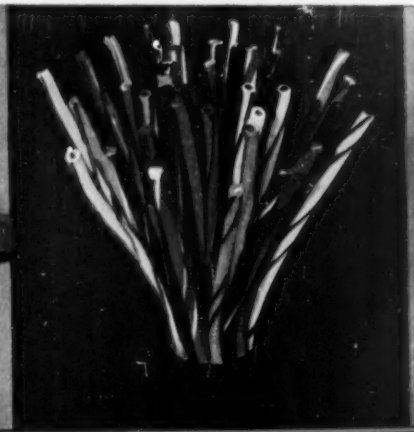
**Vinylite** BRAND **PLASTICS**

BAKELITE DIVISION

BAKELITE DIVISION
*Union Carbide and Carbon Corporation*
30 East 42nd Street, New York 17, N. Y.

**IMPROVED APPEARANCE.** Tooth powder container tops of lighter-than-water BAKELITE Polyethylene Plastic are flexible and snap-tight fitting. Water has no effect on them. They're colorful, too, and easily molded at low cost. Produced by Sameric Incorporated, Riverdale, N. J.

**RELIABLE INSULATION** is provided for this electric circuit control cable—by color-keyed VINYLITE Plastic insulation on the conductors, and a BAKELITE Polyethylene outer jacket for lasting protection against oil, water, chemicals. By Anaconda Wire & Cable Co., 25 Broadway, New York, N. Y.



**EASILY FORMED.** Soft, flexible puppet and doll heads of complex shape are now formed of VINYLITE Dispersion Resins. These compounds are durable. They resist grease, oil, chemicals. They come in all colors. Heads made by Geneve Mfg. Corp., 1731 No. Olden Ave. Ext., Trenton, N. J.

# Here's Another Motor that Won't Burn Out...

## KLIXON PROTECTORS Prevent Motor Burnouts, Reduce Repairs and Replacements

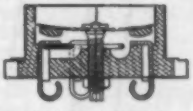
Burnout . . . not the motor illustrated because the motor manufacturer has included inherent overheat protection by building-in a Klixon Protector.

Out of sight and out of mind, the Klixon Protector keeps constant guard . . . always ready to shut the power "off" should the motor become dangerously overheated. When it cools to a safe operating temperature it snaps the power "on" again automatically. And because it is built-in by the manufacturer, the Klixon Protector and motor provide a tested combination that assures long motor life.

Motor manufacturer after manufacturer extend the life line of their motors by including Klixon Protectors . . . automatic reset types that recycle automatically . . . manual reset types that require the "red button" to be pushed to reclose the circuit.

Protect your motor-driven products by using and specifying motors with built-in Klixon Protectors. Also request that transformers, solenoids, variable voltage transformers and other electrical equipment have Klixon overheat Protectors.

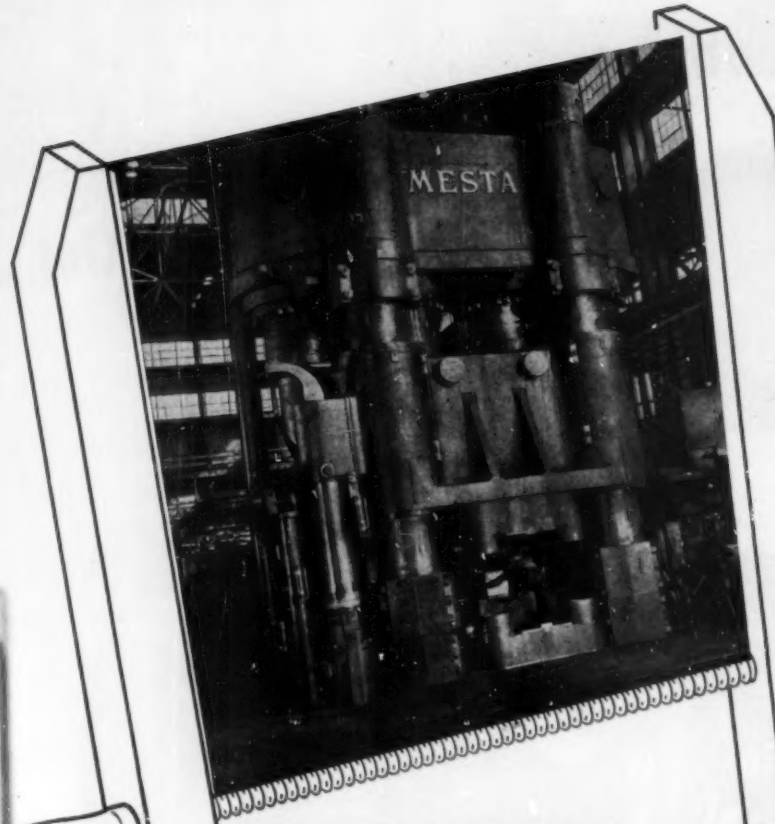
### HOW KLIXON PROTECTORS WORK!



**CLICK . . . IT'S OFF!**
Should a motor become overheated and dangerously hot, the Klixon Protector snaps the power "off" preventing the motor from burning out.

**CLICK . . . IT'S ON!**
When the motor cools to safety, the Klixon Protector snaps the power "on" automatically, or by pushing the red button when the manual reset type is used.

**SPENCER THERMOSTAT** Division of Metals & Controls Corporation — KLIXON — 983 Forest St., Attleboro, Mass.




*Magnesium and Aluminum alloys are being forged in parts up to 500 lbs. in weight on this huge 18,000-ton press in Wyman-Gordon Company's plant, Worcester, Mass. This press weighs 5,000,000 pounds, is 32' high and has a platen area of over 88 sq. feet.*

# This 36,000,000 pound squeeze uses plenty of VIM

The largest press in America, shown above, depends on VIM Leather Packings. There are some 89 different packings and 117 washers used on this huge 18,000-ton press, installed four years ago by Mesta and used primarily for forging aircraft light metal forgings.

Recently an emergency service job was needed, and Houghton hydraulic engineers came through with first-aid in a hurry, a job that in the words of the master mechanic was "very fine and very much appreciated. . . . The packings are working fine . . . no leakage whatsoever."

That praise indicates the best of packings and of service, a two-fold assistance for which Houghton is noted wherever hydraulics are used.

This press also uses our *Hydrolubric* No. 2 in its water system to lubricate valves—aiding hydraulic operation.

What we can do for mammoth presses we can likewise accomplish for all hydraulic designs, wherever packings are required. We supply a complete line of leather *and* synthetic rubber packings, including "O" rings. For new "Packings Standards" book, write E. F. Houghton & Co., Philadelphia 33, Pa.

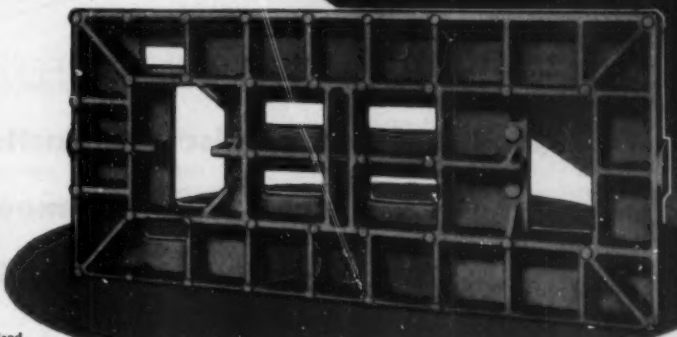
**HOUGHTON'S VIM LEATHER AND VIX-SYN** *Engineered Packings*

# 21,568 TIMES HEAVIER!

WEIGHT 1 OUNCE

## Both Castings are ALUMINUM ...both by PERMITE

WEIGHT 1,348 LBS.



This giant Permite Aluminum Sand Casting is for use in a machine for making all-steel burial caskets. Size approximately 10'x5'x1'. Net weight 1,348 lbs. The tiny 1 oz. Permite Permanent Mold Aluminum Casting above is a hydraulic brake piston.

DEMONSTRATED versatility in size and type of aluminum castings produced is but one of the reasons why the Permite foundries are leaders in the production of aluminum castings by the permanent mold, semi-permanent mold, sand or die casting processes.

Permite offers the services of expert metallurgists to aid you in the selection of the alloy that will, at the lowest cost, best fit the needs and specifications of your particular casting problem.

If desired, Permite casting specialists are available to advise you on the changes in structural design that will increase strength and effect possible economies in metal and machining.

Whatever your requirements as to size or type of aluminum casting, forward blue-prints today for free recommendations and estimates.

ASK FOR NEW 80-PAGE CASTING MANUAL

Authoritative illustrated manual on the design, production and application of aluminum castings. Includes casting alloys tables. Sent free on request to interested executives.

PERMITE

## ALUMINUM INDUSTRIES, INC.

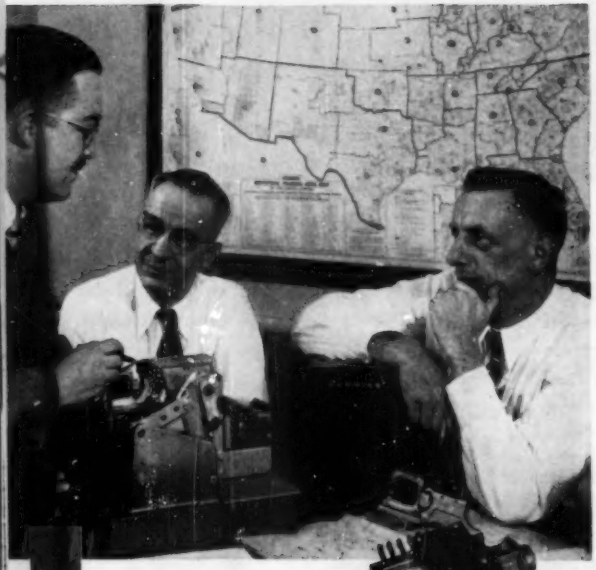
CINCINNATI 25 OHIO

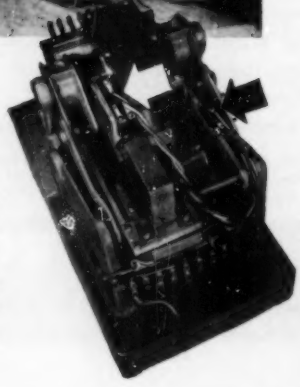
ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS

# MICRO SWITCH ENGINEERING —experience

FIELD SERVICE

## How MICRO SWITCH ENGINEERING* produced two precise snap-action switches to meet exacting requirements of this business machine





Arrows show location of MICRO precision switches in perforating machine. One switch (left arrow) is especially adapted to take high inrush current. The other (right) is an even smaller switch which provides an efficient interlock to prevent double perforation.

A Midwestern manufacturer of business machines was faced with need for two precise snap-action switches to meet the requirements of a streamlined perforating machine.

First, he required a switch that could handle the high inrush starting current on both a-c and d-c loads. This switch must be small, accurate and dependable over a long life. A second switch was needed which must fit into an even smaller space and provide an interlock to prevent double perforation.

Contact was made with MICRO SWITCH ENGINEERING and both requirements were met. Cooperation between MICRO SWITCH and the manufacturer's engineering staff made trial and error methods unnecessary.

Prompt, successful solution of special problems that involve precise, snap-action switches is "right down MICRO's alley." The skill, imagination and experience of MICRO engineers have developed more than 4600 different varieties of snap-action switches . . . many of them created to meet highly individualized application needs.

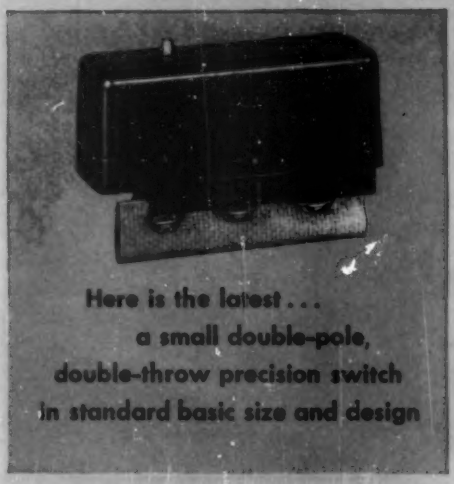
Improvement of *your* product from the standpoint of efficiency, streamlining or saleability may easily result from your taking advantage of MICRO SWITCH ENGINEERING. We invite your inquiry.

# helps make good products better!

PRODUCT DEVELOPMENT

ADAPTABILITY STANDARDS

**MICRO SWITCH ENGINEERING* has served design engineers with more than 4600 types of precise snap-action switches!**



**Here is the latest . . . a small double-pole, double-throw precision switch in standard basic size and design**

This new MICRO precision snap-action switch provides a double-pole, double-throw circuit in standard basic switch size.

It is designed to provide simultaneous snap-action operation of both poles regardless of the speed of operation.

A full line of MICRO housings and actuators is available to provide supplementary operating means and facilitate mounting and installation.

This new switch is but one of the constantly growing number of MICRO precision switches . . . now numbering more than 4600 types . . . which MICRO SWITCH ENGINEERING has made available to design engineers.

**MICRO SWITCH ENGINEERING* offers types of actuators to meet every design requirement**

1. **PIN PLUNGER** where accurate repetition of operating point is a prime requisite.
2. **"S" PLUNGER** for application where travel of actuating device is less accurately controlled.
3. **"D" PLUNGER** large diameter plunger to facilitate operation by slow-moving cams.
4. **"Q" PLUNGER** for manual or mechanical push-button switches to be mounted through panel.
5. **LEAF ACTUATOR** for use by operating means which combine small force with limited overtravel.
6. **ROLLER LEAF ACTUATOR** suited for actuation by clock motors and other low-energy means.
7. **"W" LEVER** designed for operation by slow-moving cams or slides and similar actuating means.
8. **"W2" ROLLER LEVER** with roller assembly at lever tip . . . for fast-moving cam actuation.
9. **"W22" ROLLER LEVER** for actuation by fast-moving cams where compactness is an important factor.

**MICRO . . . first name in precision switches**

© 1950 First Industrial Corp.

MICRO MS SWITCH

A DIVISION OF FIRST INDUSTRIAL CORPORATION

FREEPORT, ILLINOIS, U. S. A.

**BRANCH OFFICES:** Chicago • New York • Boston • Cleveland • Los Angeles

**SALES REPRESENTATIVES:** Portland • St. Louis • Dallas • Toronto

WE
WELCOME
SMALL
ORDERS
B
B

# For lightweight rigid construction you can't beat die castings of Dow

# MAGNESIUM

## the world's lightest structural metal!

Magnesium die castings have supplied an economical answer to many tough design problems.

A leading electric typewriter manufacturer is using six magnesium die castings in his latest model. They form the side covers, main frame, top and rear cover, and keyboard guard rail. Magnesium die castings gave him the required stiffness at minimum weight and in addition, magnesium die casting alloys do not "creep" or "grow", so close tolerances could be maintained. Magnesium's unexcelled machinability made the required machining fast and economical. The variety of finishes to which magnesium is adapted made it possible to use an attractive, nonglare paint finish.

Best of all, you don't have to pay a premium price to get the advantages offered by magnesium die castings. They are generally competitive with castings in other metals, and in some cases cheaper.

For technical and design information about magnesium die castings, call your nearest Dow sales office or write direct.

*Magnesium Division*

**THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN**

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit
Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

*Many applications prove magnesium sound and economical*

Business machines are just one field where magnesium die castings have proved their worth. Portable tool housings, optical instruments, printing equipment, and reciprocating machinery are a few of the other uses that have established magnesium as a sound, economical die casting material. Investigate magnesium! See for yourself what it can do to improve your product.

***Lighter Products Sell—make your product Magnesium Light!***

check Check those publications (above) you want for your particular applications and mail today to

Apparatus Dept., Sect. C 720-8,
General Electric Company,
Schenectady 5, N. Y.

Name .....

Company .....

Address .....

City ..... State .....

—CUT ALONG DOTTED LINE—

# send for these Free Bulletins for your heating jobs

**HEATING LIQUIDS** "Built-in" electric heat makes your product a better product because it *puts the heat right where it is wanted!* "Immersion heating" with G-E Calrod* heaters places heat source into the material to be heated . . . for maximum heat transfer with minimum heat losses.

**HEATING PIPELINES** G-E heating cable and Calrod tubular heaters keep viscous liquids free-flowing and protect pipelines and valves in cold weather . . . a wealth of "how to" information on installation, application and power requirement calculation.

**HEATING PROCESS AIR** How and where to apply G-E strip, Calrod tubular and fin Calrod heaters for drying, baking, warming, curing and a wide range of industrial processes and equipments.

**HEATING SURFACES** Whether it's an eighth-inch soldering iron tip or 100 square-feet of platen surface, this bulletin tells you how to calculate your heating requirements . . . which G-E Calrod heater to use and where and how to install it.

**MELTING SOFT METALS** Here's how you can achieve fast melting and fully automatic temperature control of babbitt, solder, lead, tin, and type metals—with reduced operation costs, less maintenance, and cooler working conditions.

**ELECTRIC HEATERS AND HEATING DEVICES** New revised catalog lists a wide variety of heaters and devices to meet almost any conceivable heating requirement.

**DON'T MISS "HEAT—WHERE YOU WANT IT"** Latest sound slide-film in the *MORE POWER TO AMERICA* series depicts case histories of the above five basic applications of electric heat. Ask your local power company representative or contact the nearest G-E Sales Office.

**BEFORE** you design your electrically heated machinery or equipment . . .

**BEFORE** you convert existing installations . . . consult the G-E apparatus salesman who regularly calls on you or a G-E Industrial Heating Specialist . . . his recommendations will pay you real dividends in terms of more efficient heating and better designs. *Reg. U.S. Pat. Off.

GENERAL ELECTRIC

MR. PRODUCT DESIGNER

Improving present products?

Designing brand new ones?

Trying to cut costs?

There should be an idea in Polaroid's success story—that you could apply.

Write Monsanto today.

We'll gladly work with you.

# "Picture-in-a-minute . . . because we erased a century of habit-itis"

*says*

J. H. Booth

*Exec. Vice Pres.*
*Polaroid Corporation*

"We had to side-step the conventional, and banish a hundred years of 'habit-thinking' in our industry to even *envision* a camera that takes a picture, develops and prints it in less than a minute," continues Mr. Booth. "Once done, however, our course was clear. Our direction and purpose, research and design, methods and materials—all were free of the bonds of conventionality . . . and the new Land camera was born."

Two Monsanto plastics help make Polaroid's sensational, fast-selling camera a functional success. The spool on which negative film is wound is made of durable, easily-molded Lustrex styrene—it completely eliminates the danger of light damage that Polaroid found present with conventional metal spools. Secondly, through the use of Monsanto's vinyl butyral, components of Polaroid's unique self-developing film were effectively protected from moisture.

Monsanto's broad range of plastics have remarkably versatile properties that hundreds of manufacturers have found adapted to their product needs. Perhaps *your* products could be improved with lighter weight, or greater toughness, or lustrous, longer-lasting colors. Perhaps they could be produced at lower cost, with more pieces per material-pound and with fast, one-shot plastic moldings that eliminate costly assemblies. Investigate the great variety of properties of Monsanto's many plastics. Lustrex: Reg. U. S. Pat. Off.

*Film spool, molded of Lustrex styrene by the Morningstar Corp., Cambridge, Mass., for Polaroid Corporation, Cambridge. Protective film lining of Monsanto vinyl butyral by Shellmar Products Corp., Mt. Vernon, O.*

MONSANTO
CHEMICALS—PLASTICS
SERVING INDUSTRY WHICH SERVES MANKIND

For your convenience →

Monsanto Chemical Co., Plastics Div., Dept. PEP-37
Springfield 2, Mass.

Please send me the booklet, "What Monsanto Plastics Can Do For You."

Name & Title _____

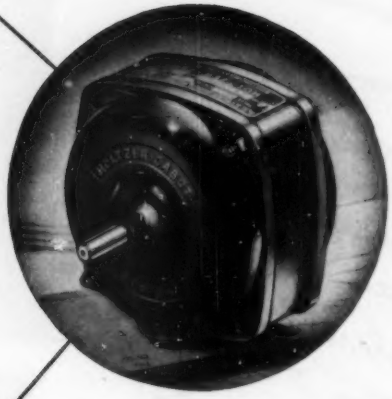
Company _____

Products Manufactured _____

Address _____

City, Zone, State _____

# HOLTZER CABOT



## FORERUNNER

Ten years ago Holtzer-Cabot instrument motors set a new standard in accuracy and compactness. Today, with ten years of refinement, these dependable products power many of the finest instruments throughout the world. Both synchronous and induction designs are in sizes up to 1/500th horsepower, gear head outputs down to 1 r.p.m. Many models can be secured from stock, or they can be built to special order. Write for complete information.

**HOLTZER-CABOT**

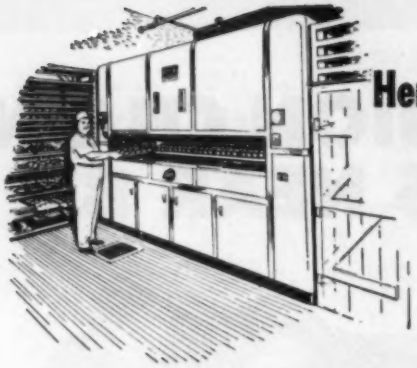
DIVISION OF NATIONAL PNEUMATIC CO., INC.

**BOSTON 19, MASSACHUSETTS**

OFFICES IN NEW YORK, PHILADELPHIA AND CHICAGO

*For applications such as Recorders, Industrial Process Controls, Tower Clocks, Timers and Traffic Controls.*

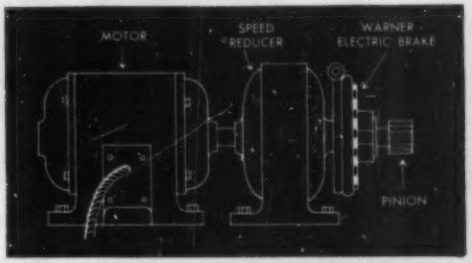
DESIGNERS AND MANUFACTURERS OF FRACTIONAL HORSE-POWER ELECTRIC MOTORS FOR THREE-QUARTERS OF A CENTURY



# Here's how smart designers are solving their problems of clutching, braking, automatic control, shock and torque by using WARNER ICB UNITS

## ●IF YOUR PROBLEM

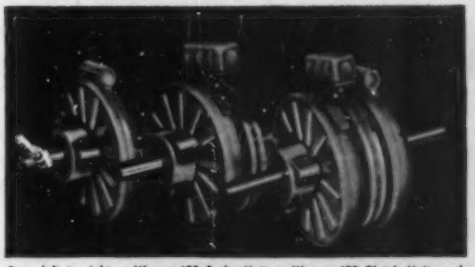
is to design your machine or its activating parts so that *you get:* (1) Push-button actuation at the machine or a remote control panel. (2) Fully or semi-automatic operation in "stop" or "start" of machine cycles. (3) Controlled acceleration or deceleration. (4) Automatic or manual adjustment of torque to load . . . or if your problem is *to eliminate:* (1) "Shock" from stop or start on gear trains and shafts. (2) Complex mechanical lever linkage, or air and hydraulic piping systems. (3) Vibration and hammering from solenoid operated brakes and clutches . . . or if you want to *increase production* from your machine by increasing the speed and number of cycle operations —




*A WARNER ICB Unit installed on the drive of Rotary Baking Oven. Provides automatic positioning of trays for loading and unloading in continuous operation. Allows manual or automatic control.*

## ●A GOOD SOLUTION

to any one or combination of these problems is WARNER ICB Units. WARNER ICB Units are electrically controlled and operated clutches and brakes. They are compact, mechanically simple and may be applied to machine spindles, drive shafts, or direct to electric motors. Because of their design, they may be operated individually or in combination, manually or automatically, by direct or remote control. They provide for infinite controlled variation of torque in either clutching or braking action within their rated capacities. Their action is smooth and shockless—fast and practically noiseless. They are self-adjusting and self-compensating for life. Their design guarantees a high rate of heat dissipation.



*From left to right: a Warner ICB Brake Unit, a Warner ICB Clutch Unit, and a combination Warner ICB Clutch and Brake Unit. Note clean, smooth, compact, appearance — simple mechanical parts.*

## ●MORE INFORMATION

on WARNER ICB Units and their application as clutches or brakes to various kinds of machinery is available. They may be used on continuous or intermittently operated machines. There is a complete range of sizes to meet both braking and clutching torque needs. If you have a design problem such as indicated above, write today for our free bulletin No. 701. If possible, state your problem. Not only will you receive your bulletin copy, but experienced WARNER ICB engineers will be glad to consult with you without obligation. Write direct to WARNER ELECTRIC BRAKE MANUFACTURING COMPANY, Beloit, Wis.

**Bulletin 701 contains complete specifications and description of WARNER ICB Units. See for yourself how they offer advantages never before available on industrial clutches and brakes. Write for it today — no charge.**

WARNER
ICB UNIT

**WARNER ICB Units are manufactured by Warner Electric Brake Mfg. Co. — pioneers in the field of electric brake design and application since 1927.**

*Wherever You are...*

# UNION CHAIN IS NEAR BY

**Suppose you need UNION Machine Finished Steel Roller Chain...**

...and are certain of the pitch, length and sprockets required. Just write or phone your nearest Union Chain Stock Carrying Distributor as listed on the facing page. More likely than not, your requirements will be shipped immediately.

***...or suppose you need*** engineering assistance in the selection of a drive or a recommendation for a conveyor application. Talk or write to Union Chain's nearest district office as listed at the top of the facing page. You will receive unprejudiced, competent help.

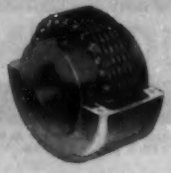
***Unprejudiced*** because Union Chain makes all types of steel sprocket chains and is interested in providing each customer with the correct chain for satisfactory service at minimum cost.

***Competent*** because Union Chain representatives are qualified through experience to make sound chain recommendations whether the application calls for roller chain, silent chain or one of the various heavy drive or conveying chains. We suggest it might profit you to discuss your chain problems with us.

UNION SILENT CHAIN

UNION HEAVY DRIVE AND CONVEYING CHAINS

UNION ROLLER CHAIN FLEXIBLE COUPLINGS



UNION SILENT CHAIN FLEXIBLE COUPLINGS

## UNION CHAIN REPRESENTATIVES

**CALIFORNIA**
American Chain & Gear Co.
C. A. Nicholas
3511 Pacific Blvd.
Huntington Park, Calif.

Hewitson Industrial Chain Co.
239-241 Twelfth St.
Oakland 7, Calif.

**GEORGIA**
N. F. Edge
208 Walton Bldg.
Atlanta, Georgia

**ILLINOIS**
Union Chain & Mfg. Co.
W. Albrecht
A. C. Mohr
B. Nelson
Room 1232
53 W. Jackson Blvd.
Chicago, Illinois

**INDIANA**
Paul W. Huddleston
5745 Guilford Ave.
Indianapolis 20, Indiana

**LOUISIANA**
F. N. Johnston, Inc.
2207 American Bank Bldg.
New Orleans, La.

**MASSACHUSETTS**
Transmission Engineering Co.
Stanley Johnson
6 Hartford St.
Newton Highlands 61, Mass.

**MICHIGAN**
Union Chain & Mfg. Co.
W. J. White
Basso Bldg.
7332 Woodward Ave.
Detroit 2, Michigan

**MINNESOTA**
F. N. Bathke
490 N. Snelling Ave.
St. Paul, Minn.

**MISSOURI**
J. B. Fleherty
5473 Delmar Blvd. Rm. 206
St. Louis, Missouri

Ed Schiefelbein
1425 Troost Ave.
Kansas City 6, Mo.

**NEW YORK**
John B. Foley, Jr.
107 Tully St.
Syracuse, New York.

Mayo & Giessen, Inc.
30 Church St.
New York 7, New York

Potter & Duggan
29 Wilkeson St.
Buffalo, New York

**NORTH CAROLINA**
M. R. Snyder Co.
304 E. Tremont Ave.
P. O. Box 3341
Charlotte 3, N. Carolina

**OHIO**
Union Chain & Mfg. Co.
F. N. Dalrymple
F. Smiley
Marshall Bldg.
Cleveland, Ohio

J. T. Young
Station A—Box 44
4860 W. Fork Rd.
Cincinnati 23, Ohio

**OREGON**
J. W. Minder Chain & Gear Co.
307 S. E. Hawthorne Blvd.
Portland 14, Oregon

**PENNSYLVANIA**
F. R. Magill
44 McKnight St.
Pittsburgh 20, Pa.

David Davies
P.O. Box 4
Plymouth, Pa.

Union Chain & Mfg. Co.
John A. Shoemaker
Room 521
Schaff Bldg.
Philadelphia 2, Pa.

**TEXAS**
Union Chain & Mfg. Co.
J. H. Castleberry
E. T. Taal
918 Magnolia Bldg.
Dallas, Texas

**WEST VIRGINIA**
J. H. Ridge
P.O. Box 12
Bluefield, W. Va.

**WISCONSIN**
Union Chain & Mfg. Co.
George H. Harris
Room 508
Wisconsin Tower Bldg.
606 Wisconsin Ave.
Milwaukee 3, Wisconsin

### SPECIAL Representatives

**NEW YORK**
Frank L. Allen
82 Wall St.
New York 5, New York

E. F. Gehres
500 Fifth Ave.
New York, New York

### FOREIGN Representatives

**ARGENTINA**
Stevens & Villaruso
Muñecas 110
Tucuman, Argentina

**BRAZIL**
W. G. Winslow
Rua Xavier de Toledo
No. 70 5° Andar
Caixa Postal 6064
Sao Paulo, Brazil

**CUBA**
Central Machine & Trading Co., S.A.
Lamparilla 208
Havana, Cuba

**HAWAII**
P. S. Pell & Co.
88 S. Queen Street
Honolulu, T. Hawaii

**MEXICO**
Thomas M. Nevin Y. Cia. S.A.
Manuel Maria Contreras 58
Mexico, D. F., Mexico

**PHILIPPINES**
The Edward J. Nell Co.
1450 Arlegui St.
Manila, Philippines

**PUERTO RICO**
Manuel Peter, Jr.
P. O. Box 2969
San Juan 12, Puerto Rico

**SOUTH AFRICA**
Robins Conveyors (South Africa) Ltd.
Sankey House
Cor. Troye & Marshall Sts.
P. O. Box 4726
Johannesburg, S. Africa

## UNION CHAIN STOCK CARRYING DISTRIBUTORS

**ALABAMA**
Alabama Bearing Co., Inc.
182 Jefferson St.
Montgomery, Alabama

Owen-Richards Co., Inc.
1009 Second Ave., North
Birmingham, Alabama

**ARKANSAS**
North Arkansas Equipment Co.
930 N. College Ave.
Fayetteville, Arkansas

**CALIFORNIA**
American Chain & Gear Co.
3511 Pacific Blvd.
Huntington Park, Calif.

Hewitson-Industrial Chain Co.
239 Twelfth St.
Oakland, Calif.

Valley Belting & Equipment Co.
2909 Los Angeles St.
Fresno, Calif.

**CONNECTICUT**
Metro Equipment Co.
Wall & Water Sts.
Bridgeport 3, Connecticut

**DELAWARE**
L. W. Rapkin Co.
Third St. & Shipley
Wilmington 40, Delaware

**FLORIDA**
Ellis & Lowe Co., Inc.,
302-306 S. Morgan St.
Tampa, Florida

Farquhar Machy. Co.
720 West Bay St.
Jacksonville, Florida

General Equipment & Supply Co.
704 N. E. First St.
Miami, Florida

**GEORGIA**
Georgia Hardware & Supply Co.
307 N. Washington St.
Albany, Georgia

Macon Supply Co.
Macon, Georgia

Richmond Supply Co.
Augusta, Georgia

John D. Robinson Co.
13 Bay Street, West
Savannah, Georgia

**GEORGIA**
Travis Belting & Supply Co.
P.O. Box 289
Griffin, Georgia

J. M. Tull Metal & Supply Co.
285 Marietta St., N.W.
Atlanta 3, Georgia

**ILLINOIS**
Dodge-Chicago Ind. Equip. Co.
450 S. Wabash Ave.
Chicago 16, Illinois

Hagerty Bros. Co.
923 S. Washington St.
Peoria 2, Illinois

W. M. Hales Co.
Hillsboro, Illinois

W. M. Hales Co.
W. Frankfort, Illinois.

Mid-States Industrial Corp.
2401 Eleventh St.
Rockford, Ill.

**INDIANA**
Diamond Supply Co., Inc.
616-24 N.W. Second St.
Evansville, Indiana

Service Equipment Center, Inc.
Indianapolis, Indiana

**KANSAS**
Bearing Service Co.
340 N. St. Francis Ave.
Wichita 5, Kansas

W. A. Thomas Supply Co.
113-114 West Third St.
Pittsburgh, Kansas

**KENTUCKY**
Sherman Bros. Mill Supply
222 South Second St.
Louisville, Ky.

**LOUISIANA**
Dixie Bearing & Supply Co., Inc.
732 N. 41st St.
Baton Rouge, La.

Weeks Supply Co., Ltd.
Monroe, Louisiana

Woodward Wight & Co.
New Orleans, La.

**MARYLAND**
Hagerstown Equipment Co.
Maryland Ave. & Memorial Blvd.
Hagerstown, Md.

M. F. Holland Co.
Lee & Sharp Sts.
Baltimore, Md.

**MASSACHUSETTS**
Bellamy-Robie, Inc.
45 Main St.
Cambridge, Mass.

**MINNESOTA**
F. N. Bathke Co.
490 N. Snelling Ave.
St. Paul, Minn.

Iron Range Equipment Co.
Hibbing, Minnesota

**MISSOURI**
Bearing Distributors Co.
1919 Baltimore Ave.
Kansas City 10, Missouri

Industrial Equipment Corp.
325 E. Walnut St.
Springfield, Missouri

Teuscher Pulley & Belting Co.
801-805 N. Second St.
St. Louis, Missouri

Wilkins-an Machine & Supply Co.
224 S. Third St.
St. Joseph 3, Missouri

**NEW JERSEY**
Burton Supply Co.
390 Union Ave.
Paterson, N. J.

Old Reliable Supply & Equipment Co.
11th & Newton Sts.
Camden, N. J.

Trenton Industrial Supply Co.
542 E. State St.
Trenton, N. J.

**NEW YORK**
Industrial Bearing & Supply Co.
148 Hillside Ave.
Jamaica, N. Y.

Lawrence Belting Co.
111 Chambers St.
New York, New York

Power Drives, Inc.
562 S. Park Ave.
Buffalo, New York

Transmatic Equipment Co.
11 North Pearl St.
Albany, New York

U. S. Inc.
600 South West St.
Syracuse, New York

Ulster Foundry Corp.
20 St. James St.
Kingston, New York

**NORTH CAROLINA**
Piedmont Mill Supply Co.
P. O. Box 130
Salisbury, N. Carolina

**OHIO**
Brubaker Gear & Mfg.
Barberton, Ohio

C. J. Edwards Co.
2005 Euclid Ave.
Cleveland 3, Ohio

Lima Armature Works, Inc.
440 N. Main St.
Lima, Ohio

Mill & Factory Supply Co.
217–10th St.
Toledo, Ohio

**OKLAHOMA**
Ore Reclamation Co.
301 N. Connell Ave.
Pitcher, Oklahoma

C. P. Dagwell Co.
816 W. Main St.
Oklahoma City, Okla.

**OREGON**
Electric Steel Foundry
Eugene, Oregon

Fisher Bros. Co.
522 Bond St.
Astoria, Oregon

Industrial Machinery & Supply Co.
1410 Adams Ave.
La Grande, Oregon

Industrial Steel & Supply Co.
North Bend, Oregon

Klamath Machinery Co.
Klamath Falls, Oregon

J. W. Minder Chain & Gear Co.
307 S. E. Hawthorne Blvd.
Portland 14, Oregon

**PENNSYLVANIA**
Ace Bearing Co.
1120 Wyoming
Scranton 1, Pa.

Bush-Brenner, Inc.
370 N. George St.
York, Pa.

Industrial Supply Co.
451 E. Broad St.
Hazelton, Pa.

Industrial Transmission Machinery, Inc.
209 N. Third St.
Philadelphia, Pa.

**PENNSYLVANIA**
F. R. Magill Co.
44 McKnight St.
Pittsburgh 20, Pa.

Maximon Machine Co.
901 N. Logan Blvd.
Altoona, Pa.

Reilly Bros. & Raub
44 N. Queen St.
Lancaster, Pa.

**SOUTH CAROLINA**
Southern Mill Supply Co.
Summerville, S. Carolina

**TENNESSEE**
Hoyt N. Payne Co.
P.O. Box 942
410 E. Depot Ave.
Knoxville, Tenn.

Tennessee Machinery Co.
113-119 Third Ave., South
Nashville 3, Tenn.

Tioga Engr. & Supply Co.
260 N. Front St.
Memphis, Tenn.

**TEXAS**
Allied Belting & Trans. Co.
2614 Sylvan Ave.
Dallas, Texas

Beeson Supply Co., Inc.
1625 Washington Ave.
Houston 10, Texas

Claure & Cowan, Inc.
401 Harrison St.
Amarillo, Texas

El Paso Machine Works, Inc.
1600 E. 44th St.
El Paso, Texas

Lloyd Electric Co.
511 El Paso St.
San Antonio, Texas

**VIRGINIA**
Blue Ridge Hardware & Supply Co.
Bassett, Virginia

Mill Supplies Corp.
South Norfolk, Va.

**WEST VIRGINIA**
Smith Steel Supply Co.
130 Peninsula St.
Wheeling, W. Va.

**WISCONSIN**
Dale Industrial Supply Co.
Wausau, Wisconsin

Richard E. Ela Co.
744 Williamson St.
Madison, Wisconsin

F. D. Naber Co.
712 South Tenth Street
Milwaukee 4, Wisconsin

**The Union Chain and Manufacturing Company** **Sandusky, Ohio, U.S.A.**

TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS

# Clarke

## Floor Maintainers Depend upon G.S. for better Gearing

FRACTIONAL HORSEPOWER GEARING

THE Clarke Sanding Machine Company of Muskegon among other things stresses "Noiseless operation", "Rugged construction", and "Dependable year after year performance", in connection with their excellent Floor Maintainers. One of the chief factors responsible for the remarkable service and satisfaction these fine machines give is the precision cut G.S. Gearing used for power transmission. Smooth, quiet, long-lived and *dependable* G.S. Fractional Horsepower Gearing is chosen by more and more of our country's leading manufacturers from coast-to-coast. ★ If *you* have a problem in which *production runs* of *better* Small Gearing is involved by all means put it up to G.S. today!

**SEND FOR** our 4-page catalog-bulletin. It illustrates and describes over 80 different types and applications of G.S. Small Gears, from 12 D.P. and finer. Ask for it on company letterhead, please.

# GEAR Specialties

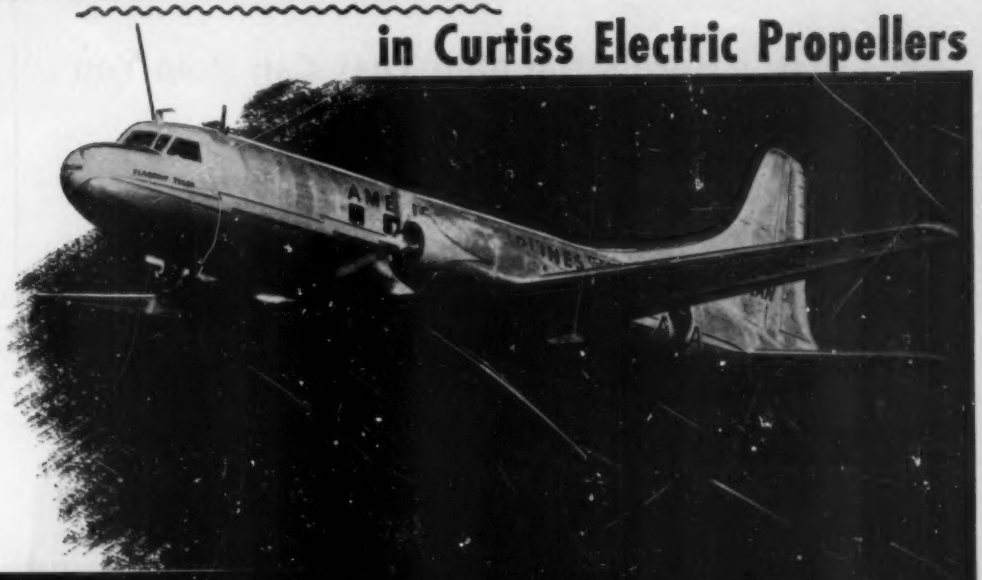
Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

2635 WEST MEDILL AVENUE · CHICAGO 47, ILLINOIS

MEMBER OF AGMA

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

# For Vital Control Circuits in Curtiss Electric Propellers



## IT'S BENDIX-SCINTILLA ELECTRICAL CONNECTORS

**CHECK THESE ADVANTAGES**

- Moisture-proof
- Radio Quiet
- Single-piece Inserts
- Vibration-proof
- Lightweight
- High Insulation Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required

Unfailing dependability is the standard set by Curtiss propellers and American Air Lines in their selection of equipment.

Bendix-Scintilla is therefore the logical choice for the electrical connectors in the Curtiss Electric propellers on American Flagships.

In fact, wherever circuits must be arranged to connect and disconnect with ease and certainty Bendix-Scintilla is the choice.

Remember whenever there is no compromise with quality—it pays to specify Bendix-Scintilla electrical connectors—the *finest* money can buy.

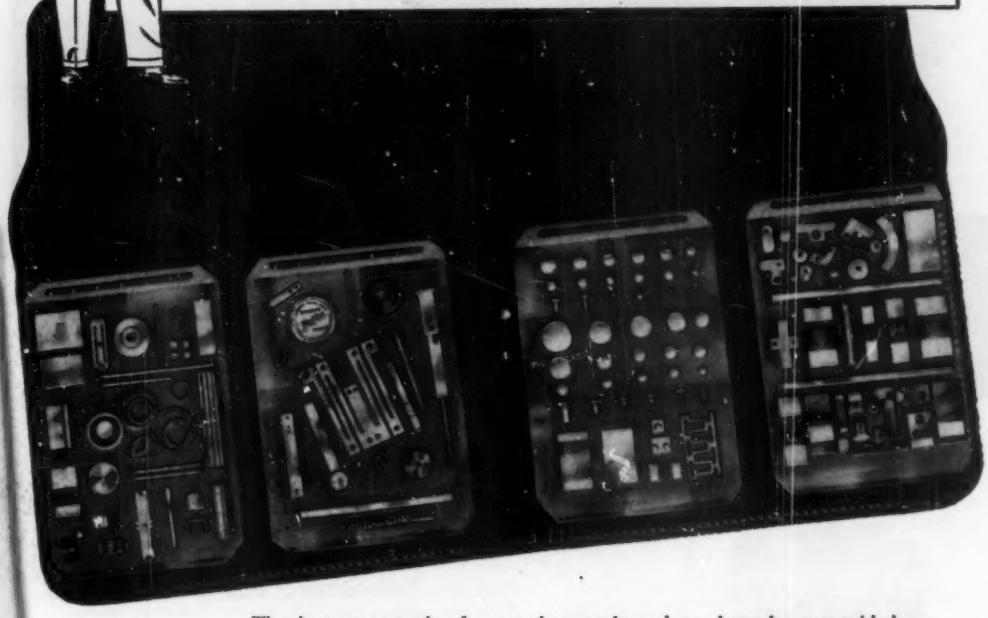
***Write our Sales Department for detailed information.***

BENDIX SCINTILLA

## Here's the Man That Can Help You

# CUT COSTS with GENERAL PLATE

***Precious and Composite Metals and Assemblies***



The best opportunity for cutting costs, increasing production and at the same time obtaining maximum performance is to investigate other metals or metal combinations. That's why we say, "A General Plate Field Engineer can help you cut costs."

Especially trained in the application of precious and composite metals for industrial uses, he is able to work with you on your specific problems. He will not give you a build-up on generalities, but will talk your problem over with you and come up with an answer that usually means savings for you.

A General Plate Field Engineer will show you how base to precious combinations save dollars by eliminating a large waste of precious metal . . . how base to base metals provide physical properties not found in single metals. And best of all, he can help you apply them to your products. He will also show you proof where General Plate Composite metals and products have provided an economical solution to the problem.

Remember, too, General Plate Field Engineers are backed-up by an extensive resident research laboratory that is always available for help on your unusual requirements.

Look for the General Plate Field Engineer and his "proved performance list." He'll show you how you can benefit at a savings with General Plate Products. Write for his services, today.

**GENERAL PLATE PRODUCTS INCLUDE:**

- Truflex Thermostat Metals
- Precious to base metal laminations
- Base metal laminations
- Alcuplate (copper on aluminum)
- Silver solders
- Laminated contacts, buttons, rivets
- Platinum — fabrication — refining
- Age-hardening Manganese Alloy 720

## GENERAL PLATE

*Division of Metals & Controls Corporation*

**603 FOREST STREET, ATTLEBORO, MASSACHUSETTS**

# * What do you mean—"*How much?*"

**You're** buying gears. You naturally want to know "*How much?*"

**How much** what?

**How much** they will cost per unit on delivery? That's *one* important consideration, but not the only one by any means.

**How much** will they save on installed cost?

**How much** will they add to the saleability, performance, and endurance of your product?

**How much** (or how little) will they crowd tolerance limits?

**How much** will they relieve you of service headaches and expenses?

**How much** will they reflect the experience, integrity, and skill of their makers?

**And how much** will the manufacturer respect your delivery requirements?

When your "*How much?*" means all this—and not just first price alone—you're talking "Double Diamond" language. You're speaking of long-term value and long-term thrift, of lowest final cost. You're buying gears on the basis that has steadily built "Double Diamond" volume and reputation through almost thirty-five years of gear-making.

DOUBLE DIAMOND
TRADE MARK
GEARS

*Made by*

**Automotive Gear Works, Inc.**

RICHMOND, INDIANA

• • • • • • FOR AUTOMOTIVE FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS • • • •

®Reg. U.S. Pat. Off.

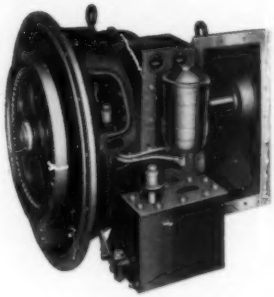
# Most Popular Item...

## IN THE STEEL ERECTION BUSINESS

● Because Twin Disc Hydraulic Torque Converters permit exact "spotting" of heavy steel beams without jerkiness, contractors engaged in steel erection specify them as a "must" on their lift cranes.

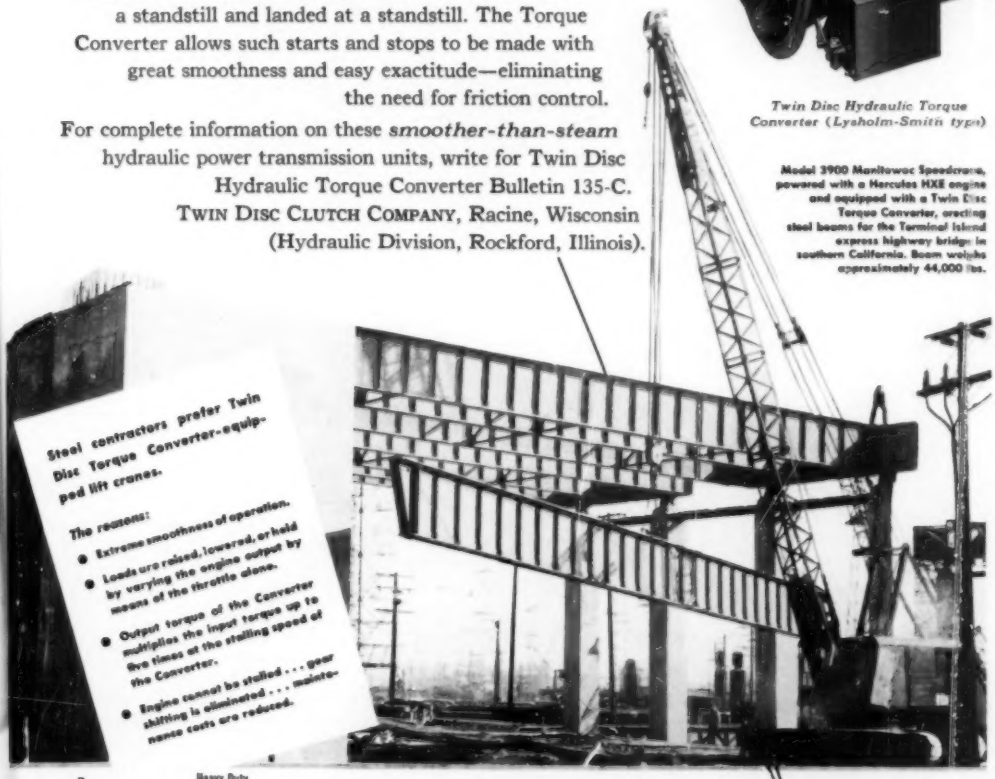
In this type of work, where both the travel and hoisting mechanisms are used more frequently than in other types of construction work, every load has to be started from a standstill and landed at a standstill. The Torque Converter allows such starts and stops to be made with great smoothness and easy exactitude—eliminating the need for friction control.

For complete information on these *smoother-than-steam* hydraulic power transmission units, write for Twin Disc Hydraulic Torque Converter Bulletin 135-C. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).



*Twin Disc Hydraulic Torque Converter (Lysholm-Smith type)*

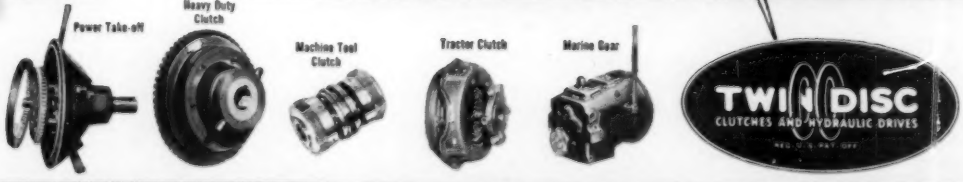
**Model 3900 Manitowoc Speedcrane, powered with a Hercules HXE engine and equipped with a Twin Disc Torque Converter, erecting steel beams for the Terminal Island express highway bridge in southern California. Boom weighs approximately 44,000 lbs.**



**Steel contractors prefer Twin Disc Torque Converter-equipped lift cranes.**

**The reasons:**

- **Extreme smoothness of operation.**
- **Loads are raised, lowered, or held by varying the engine output by means of the throttle alone.**
- **Output torque of the Converter multiplies the input torque up to five times at the stalling speed of the Converter.**
- **Engine cannot be stalled . . . gear shifting is eliminated . . . maintenance costs are reduced.**




**SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918**

FOURTH OF A SERIES

# Know Your Plastics

## IT MAY MEAN BETTER AND FASTER PRODUCTION... AT LOWER COST!

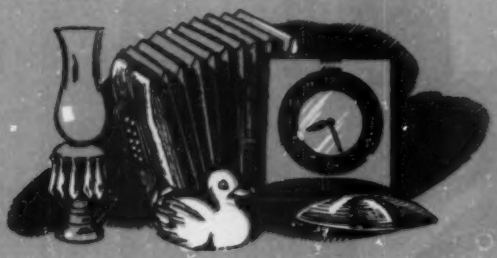
When you investigate plastics for your new or redesigned product, think first of BAKELITE Plastics. The BAKELITE family of plastics includes those in greatest demand. This gives you a wide selection, all from one supplier. The chances are that you will find the one plastic that is best suited to your production facilities, and also the plastic that gives the best qualities to your finished products at the lowest possible cost!

***This message deals with "BAKELITE" STYRENE PLASTICS***

### BMS4—CLEAREST STYRENE AVAILABLE

This unmodified BAKELITE Styrene Plastic is lending its exceptional qualities to a host of uses demanding utmost purity and clarity. In water-white crystal form, its purity and clarity are unsurpassed by any polystyrene now on the market. In transparent colors, it displays a jewel-like depth of light and luster. Color dispersion in both transparent and opaque materials is absolutely uniform.

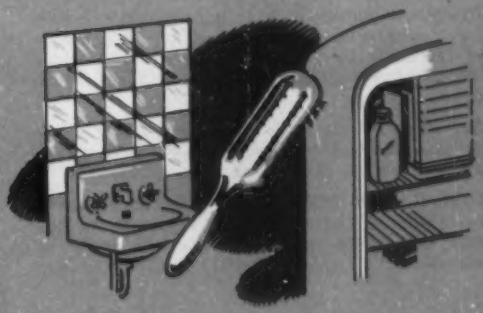
*Typical uses:* Colored jewels and spangles, clear sheets for mock-ups and models, transparent boxes, clock lenses, toys and games.



### BMS6—EASY-FLOW STYRENE

This is a lubricated grade of BMS4. The physical properties of items molded from BMS6 are identical with those of BMS4, except for slightly less clarity. Easy flow in the mold and excellent mold release are outstanding characteristics. Pouring of granules from hopper to cylinder may be accurately controlled, for utmost uniformity of feed.

*Typical uses:* Brush backs, wall tiles, refrigerator breaker strips.



### BMS7—HEAT-RESISTANT STYRENE

This material is distinguished by greater stability at elevated temperatures than is obtainable with general-purpose polystyrene molding materials. Molded pieces will withstand short-time immersion in boiling water without distortion. Moreover, BAKELITE BMS7 material has the same outstanding clarity in crystal form as BAKELITE BMS4.

*Typical uses:* Dinnerware, food bowls, kitchen utensils, pipe mats.

### BMS8—LUBRICATED HEAT-RESISTANT STYRENE

This material possesses all of the essential qualities of BAKELITE BMS7 material, but is relatively easier to mold because it is lubricated. Clarity is reduced slightly. Its bulk factor is highly favorable to economical production. Its molding properties are excellent, leading to worthwhile production economies.

*Typical uses:* Tumblers, beer and cocktail glasses, radio cabinets.

BAKELITE Styrene Plastics are supplied in several grades to satisfy the varied requirements of literally thousands of end uses. These grades, designated BMS4, BMS6, BMS7, and BMS8, are described above. Other grades, developed for highly specific end uses, are available at present in limited quantities for experimental product development. To help you choose the correct BAKELITE Styrene Plastic call upon BAKELITE technical representatives who are located in major industrial centers throughout the country. Write Dept. P-10.

Bakelite TRADE-MARK Styrene PLASTICS

BAKELITE DIVISION UCC

BAKELITE DIVISION, *Union Carbide and Carbon Corporation*, 30 East 42nd Street, New York 17, N. Y.

# Can You Use a HEAVY liquid?

Can you use a heavy liquid that has contributed greatly to simplifying design and fabrication of certain products?

Acetylene tetrabromide is an unusually heavy liquid with a specific gravity of 2.95. It is stable in dry air in the absence of sunlight and, when sealed in an opaque container, will not break down.

Acetylene tetrabromide is comparatively inexpensive and finds wide use as a gauge fluid and as the movable part in vibration dampeners.

GIVE A SEARCHING LOOK at the properties of acetylene tetrabromide. Then, if you desire further information or technical service, write or wire Dow.

$C_2H_2Br_4$

***Properties:***

Clear, colorless liquid with a mild sweet odor.

| | |
|---|---|
| Specific gravity at 25/25°C. | 2.953 |
| Pounds per gallon at 25°C. | 24.57 |
| Boiling point at 15 mm. Hg | 119°C. |
| Freezing point | 0.0°C. |
| Fire point | None |
| Flash point | None |

***Solubility, grams per 100 grams solvent:***

| | |
|---|---|
| Alcohol at 25°C. | ∞ |
| Carbon Tetrachloride at 25°C. | ∞ |
| Chloroform at 25°C. | ∞ |
| Ether at 25°C. | ∞ |
| Water at 30°C. | 0.065 |
| Water at 80°C. | 0.28 |

**THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN**

**Send for free sample of ACETYLENE TETRABROMIDE**

**The Dow Chemical Company**
**Dept. 1-H**
**Midland, Michigan**

**Name**_____ **Title**_____

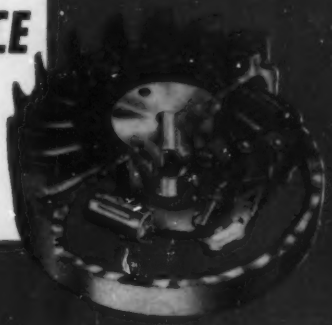
**Company**_____

**Address**_____

**City**_____ **State**_____

**DOW**
**CHEMICALS**
INDISPENSABLE TO INDUSTRY AND AGRICULTURE

THE
SUREST WAY
TO MEET
THE DEMAND
FOR
*QUALITY IGNITION PERFORMANCE*
IS TO



*Specify*

# BENDIX-SCINTILLA

THE MOST TRUSTED NAME IN MAGNETOS

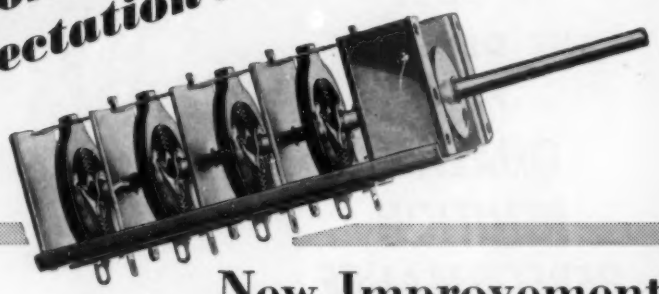
The requirement for greater quality of performance in small engines is made even more challenging by buyers' reluctance to accept cost increases. More and more manufacturers, however, are discovering that the surest way to meet these requirements is to specify Bendix-Scintilla magnetos. For these rugged lightweights give buyers all the performance features they've been looking for. And equally important, the basic Bendix-Scintilla designs make this remarkable performance available for every small engine styling—and every pricing requirement. Write us for details.

**BUILT-IN RELIABILITY**

Simplicity in design • Waterproof condenser and coil • Lower operating cost • Minimum lubrication requirements • Light in weight • Higher voltage at starting speeds • Constant spark over entire speed range • Compact and sturdy construction.

BENDIX SCINTILLA

**Value Beyond Expectation!**



# New Improvements in Mallory Inductuner* for Television Receivers

***Outstanding Advantages of the new Mallory Spiral Inductuner:***

1. A single control for easy selection and fine tuning of any television or FM channel.
2. Easily adapted to UHF converter use.
3. Excellent stability eliminates frequency drift.
4. Supplied in three- or four-section designs.
5. Far more quiet operation; permits high signal-to-noise ratio in front end designs.
6. Free from microphonics.
7. Greater selectivity on high frequency channels.
8. Eliminates "bunching" of high band channels.
9. Simplifies front end design and production.
10. Reduces assembly costs.

*Reg. trade mark of P. R. Mallory & Co., Inc. for inductance tuning devices covered by Mallory-Ware patents.

Now there are important new reasons why the Mallory Inductuner should be first choice for your TV receiver. Each one offers more convenience to the set owner, new economy for you, without any sacrifice in the performance advantages of the continuous tuning principle . . .

***Improved Inductuner eliminates "dead zone" from continuous tuning; covers entire TV range from 54 to 216 megacycles, including FM, in only 4 revolutions!***

***Improved Inductuner covers entire TV spectrum in only 3 revolutions, if FM is not required!***

***Improved Inductuner can be channel-indexed for touch-tuning without dial watching . . . still provides fine-tuning adjustment!***

***Finally, the Improved Inductuner is available at low cost and will make important savings for you in assembly and alignment operations.***

***That's Value Beyond Expectation!***

Write for technical details. Also inquire about the surprisingly low cost and superior performance of the suggested front end designs which Mallory engineers have developed around the Inductuner.

## Television Tuners, Special Switches, Controls and Resistors

**SERVING INDUSTRY WITH**

| | |
|---|---|
| Capacitors | Contacts |
| Controls | Resistors |
| Rectifiers | Vibrators |
| Special Switches | Power Supplies |
| Resistance Welding Materials | |

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

two news items of tremendous significance to the designer

**One Man Can Handle Aluminum Plate, Piano Manufacturer Reports**

Three men used to be required in the plant of Winter & Company, famous piano makers, to lift a single piano plate in the assembly process. The new Alcoa Aluminum plate now used by Winter can be lifted easily by one man, the company reports.

***Utility Rotates Derrick Trucks To Please Men***

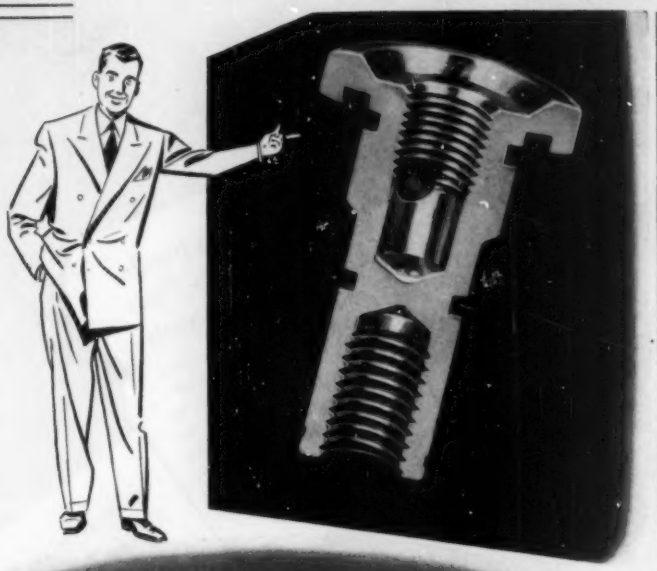
A large electric utility company recently purchased four aluminum pole derricks, used for erecting poles, and equipped a like number of trucks with them. It has become necessary to rotate these trucks among the various line crews, the utility reports. Otherwise, the men complain of favoritism shown the crews privileged to use the light, easy-to-handle aluminum derricks.

IN ADDITION TO FLAT AND COILED SHEET • ALCOA MAKES INGOT • BAR ROLLED AND EXTRUDED SHAPES • WIRE • ROD • TUBING • PIPE • SAND DIE AND PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS ELECTRICAL CONDUCTOR • SCREW MACHINE PRODUCTS • FASTENERS • FOIL FABRICATED PRODUCTS • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

ALCOA

**ALCOA FIRST IN ALUMINUM**

## THE ALCOA PRODUCTS ADVERTISED HERE ARE BACKED BY THE BASIC ENGINEERING LITERATURE OF THE INDUSTRY...



# SECONDARY OPERATIONS
## Cost Less at Alcoa!

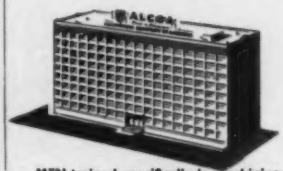
Secondary operations can make the difference between out-of-line costs or reasonable prices for screw machine products. Because they can cost you *more than primary operations* unless your screw machine supplier takes them into account at the outset.

Alcoa does just that—engineers the whole job at the start. Takes advantage of equipment specially selected for low-cost secondary work on aluminum and magnesium. Drilling, tapping, slotting, milling, press forming, stamping or marking, thread rolling, centerless grinding, and others.

That's why you can buy the best light metal screw machine parts from Alcoa *at prices no greater—possibly lower—than you've been paying for run-of-the-mill work.*

For a prompt quotation on your job, *phone* your nearby Alcoa sales office. ALUMINUM COMPANY OF AMERICA, 2128C Gulf Building, Pittsburgh 19, Penna.

### ONLY ALCOA OFFERS YOU ALL THESE UNDER ONE ROOF—




**MEN** trained specifically in machining aluminum and magnesium alloys.

**MACHINES** handling all types of rod, bar and tubing up to 3½" O.D.—from hand machines to multiple spindle automatics.

**SECONDARY OPERATIONS**—Burring, drilling, tapping, milling, slotting, press forming, stamping, marking, centerless grinding, thread rolling, others.

**FINISHING**—Tumbling, burnishing, chemical dip, oiling, buffing, color buffing, plain or colored Alumilite* finishing.

**FINISH QUALITY CONTROL**—Laboratory check of Alumilite finishes; regular production checking, final visual inspection.

**CONTINUOUS INSPECTION** by operators as well as inspectors. Begins with first piece inspection, continued by operator equipped with all necessary gages; process and final inspection employing statistical methods.

**BIG STOCK INVENTORY** that is adequate to initiate most jobs without waiting for mill shipment of stock.

**DESIGN AID** that can give you a better product or lower costs, or both. New orders are analyzed by Alcoa engineers for improvements or cost reduction.

**ASSEMBLY AND PACKAGING**—Alcoa is set up to turn out parts, finish, assemble, package and ship completed products (not necessarily all-aluminum) ready for immediate resale.

**MACHINED FORGINGS, CASTINGS, IMPACT EXTRUSIONS**—Gives you the advantages of one source for these parts and secondary operations on them.

**LOW COST, FAST DELIVERY**—Alcoa offers you all these at competitive prices and dependable delivery schedules.

*Patented Process

# ALCOA ALUMINUM

INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT-MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

**IN ADAPTING THEM TO YOUR USE, YOU ARE INVITED TO MAKE FULL USE OF ALCOA'S OUTSTANDING ENGINEERING HELP**

**Q** Can Aluminum be plated?

**A** YES

**For example...**

Any metal that can be plated, can be plated on aluminum. You can plate for decorative effect . . . electrical conductivity . . . abrasion resistance . . . joining purposes. And you'll find Alcoa's Research and Development Laboratories have the answers on technique and procedure all worked out.

Contact them when your aluminum products involve plating. You'll find that a few changes in your plating procedures and simple surface preparation are all that's required. Call your local Alcoa sales office listed in the phone book under "Aluminum", or write ALUMINUM COMPANY OF AMERICA, 2122C Gulf Building, Pittsburgh 19, Pennsylvania.

**ALCOA ALUMINUM**

INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT-MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

**THESE ALCOA PRODUCTS WERE DEVELOPED IN 62 YEARS' RESEARCH, PRODUCED BY ADVANCED ALCOA PLANT EQUIPMENT...**

# MEMO TO THE AUTOMOTIVE INDUSTRY

## ALCOA ALUMINUM SAVES on SCREW MACHINE PARTS

A remarkable saving becomes instantly obvious when you divide the cost of Alcoa Aluminum Screw Machine Stock by 3. And that's the way to compare it with brass and steel. Pound for pound you get 3 times as much. Besides costing less per foot, Alcoa Stock machines faster than other metals. Its corrosion resistance eliminates costly finishing. Start figuring your savings with a copy of the free book, "Alcoa Aluminum in Automatic Screw Machines." Write ALUMINUM COMPANY OF AMERICA, 2117C Gulf Building, Pittsburgh 19, Pennsylvania.

*Like these*

SPECIAL FASTENERS

DOOR LATCHES

CONTROL KNOBS

FITTINGS

LINKAGES

ALCOA

ALCOA *Aluminum* SCREW MACHINE STOCK

**THE ALCOA PRODUCTS ADVERTISED ON THESE PAGES ARE BACKED BY ALCOA'S RIGID QUALITY CONTROL...**

# *Figure* ALCOA ALUMINUM FORGINGS AT PRICES 40% BELOW PREWAR!

Chances are, it costs far less than you think to give your products the vital advantages of aluminum forgings. At Alcoa, new forging techniques and improved facilities have brought prices down. Why settle for less when Alcoa Forgings can give you all this?

- Light weight, combined with forged strength and compactness
- Tough, finely-knit grain structure
- Excellent, uniform physical properties
- Superior machinability
- Attractive appearance
- High resistance to corrosion
- Rapid heat transfer

This may be the answer to some of your toughest design problems. Why not look into it? Our forging engineers are ready to work with you. Just mail the coupon below, or call your nearby Alcoa Sales Office.

ALCOA

ALUMINUM COMPANY OF AMERICA
1808C Gulf Building
Pittsburgh 19, Penna.

I would like to have full information on the advantages of aluminum forgings for the following application:

_____

_____

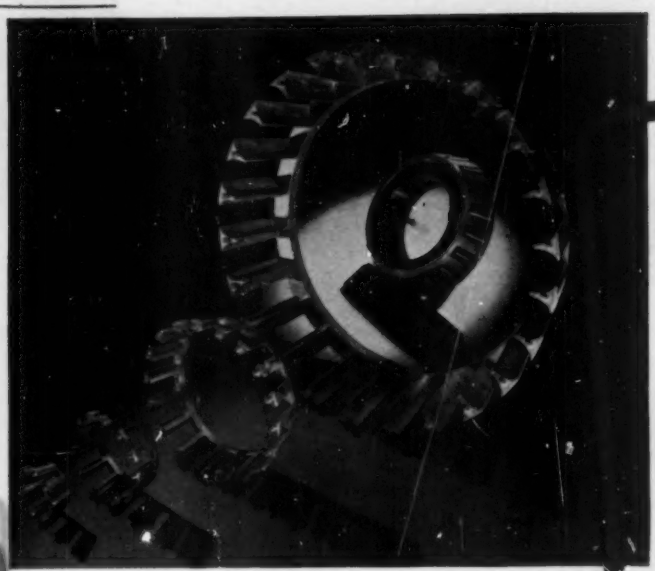
Name_____ Position_____

Company_____

Address_____

ALCOA

**ALCOA PRODUCTS ARE PROVIDED FROM ALCOA PLANTS IN CONVENIENT SEMI-FABRICATED FORMS...**



# Alcoa casts long runs at...

One of Alcoa's modern foundries is practically in your back yard. This fact puts at your disposal the most modern foundry equipment. Personnel who are old hands at light metal casting. 62 years of aluminum knowledge to improve your products.

When Alcoa casts your parts, they inherit more of aluminum's good points. Light weight. High strength. Corrosion resistance. And because of Alcoa's production facilities and experience, no one bids lower on the tough castings or the long run jobs. Sure, Alcoa casts the easy ones and the short runs, too. But we really shine on jobs that other foundries shy away from.

For a prompt quotation, call your local Alcoa sales office. It's listed under "aluminum" in your phone book. Or write ALUMINUM COMPANY OF AMERICA, 1999C Gulf Building, Pittsburgh 19, Pennsylvania.

**ALUMINUM CASTINGS by ALCOA**

ALCOA ALUMINUM

# THESE ALCOA SALES OFFICES *Will Aid You*

These sources of the Alcoa products (described on the preceding pages) are as near as your telephone. Let them serve you with engineering help, literature, and a pound or a ton of the Alcoa product that best meets your needs.

**ALABAMA**
Birmingham—505 First National Bldg.
Phone 4-8593

**CALIFORNIA**
Los Angeles—108 West 6th Street
Phone Tucker 5121
San Francisco—615 Russ Bldg.
Phone Yukon 6-6484

**COLORADO**
Denver—524 U. S. National Bank Bldg.
Phone Tabor 4638

**CONNECTICUT**
Fairfield—1333 Post Road
Phone Fairfield 9-5221
Hartford—Capitol Bldg., 410 Asylum St.
Phone Hartford 5-2192 to 5-2196

**DELAWARE**
Wilmington—Delaware Trust Bldg.
Phone Wilmington 8-4138 and 8-4139

**FLORIDA**
Tampa—1004 Tampa Theatre Bldg.
Phone 2-1984
Miami—1129 Alfred I. Du Pont Bldg.
Phone Miami 9-0651

**GEORGIA**
Atlanta—1800 Rhodes-Haverty Bldg.
Phone Cypress 4681-2-3-4-5

**ILLINOIS**
Chicago—520 N. Michigan Ave.
Phone Delaware 7-8181
Peoria—415 Commercial Natl. Bank Bldg.
Phone 3-4224 and 3-1784

**INDIANA**
Fort Wayne—1935 Lincoln Tower
Phone Eastbrook 4676
Indianapolis—817 Merchants Bank Bldg.
Phone Market 2501
South Bend—805 J. M. S. Bldg.
Phone 2-3333

**IOWA**
Davenport—503 Kahl Bldg.
Phone 2-6243 and 2-6244

**KANSAS**
Wichita—411 Fourth Natl. Bank Bldg.
Phone 5-6624

**KENTUCKY**
Louisville—1154 Starks Bldg.
Phone Wabash 7456 and 7457

**LOUISIANA**
New Orleans—627 Whitney Bank Bldg.
Phone Canal 3372

**MARYLAND**
Baltimore—400 Baltimore Life Bldg.
Phone Saratoga 8091 to 8094

**MASSACHUSETTS**
Boston—20 Providence St., Park Square
Phone Hancock 6-2638, 6-2639, 6-2640, 6-2641, and 6-2694
Springfield—507 Tarbell—Watters Bldg.
Phone Springfield 3-5103

**MICHIGAN**
Detroit—610 New Center Bldg.
Phone Trinity 1-8100
Grand Rapids—812 Michigan Natl. Bank Bldg., Phone Grand Rapids 9-0209
Jackson—1203 National Bank Bldg.
Phone Jackson 2-8206
Pontiac—301 Pontiac State Bank Bldg.
Phone Pontiac 4-1531

**MINNESOTA**
Minneapolis—1060 Northwestern Bank Bldg., Phone Atlantic 3528

**MISSOURI**
Kansas City—2300 Power & Light Bldg.
Phone Victor 3870
St. Louis—10th Floor, Continental Bldg.
Phone Franklin 6700

**NEW JERSEY**
Newark—744 Broad Street
Phone Market 2-6664

**NEW YORK**
Albany—90 State Street
Phone 4-0146, 4-0147, 6-7489
Buffalo—1880 Elmwood Avenue
Phone Riverside 2880 to 2884
New York—230 Park Avenue
Phone Murray Hill 6-8046 to 6-8058
Rochester—1331 Lincoln Alliance Bank Bldg., Phone Baker 2630
Syracuse—408 State Tower Bldg.
Phone 3-0156

**OHIO**
Cincinnati—801 Enquirer Bldg.
Phone Parkway 7700
Cleveland—1450 Terminal Tower
Phone Cherry 6880
Columbus—40 South Third Street Bldg.
Phone Adams 5251
Dayton—302 Harries Bldg.
Phone Hemlock 1112
Toledo—1801 Ohio Bldg.
Phone Main 6295

**OREGON**
Portland—510 The U. S. Natl. Bank Bldg.
Phone Atwater 6605

**NORTH CAROLINA**
Charlotte—616 Johnston Bldg.
Phone 4-9751

**PENNSYLVANIA**
Allentown—913 Hamilton Street
Phone Allentown 3-7463 and 3-7464
Philadelphia—123 S. Broad Street
Phone Kingsley 5-0250 to 5-0257
Pittsburgh—2012 Oliver Bldg.
Phone Atlantic 1-4545
York—205 Manufacturers Bldg.
Phone York 2044 and 7441

**RHODE ISLAND**
Providence—815 Industrial Trust Bldg.
Phone Jackson 1-4108 and 1-4109

**TEXAS**
Dallas—301 Thomas Bldg.
Phone Riverside 6292
Houston—1806 Commerce Bldg.
Phone Preston 7106

**VIRGINIA**
Richmond—213 Exchange Bldg.
Phone Richmond 3-8393 and 3-8394

**WASHINGTON**
Seattle—1411 Fourth Ave. Bldg.
Phone Main 1868

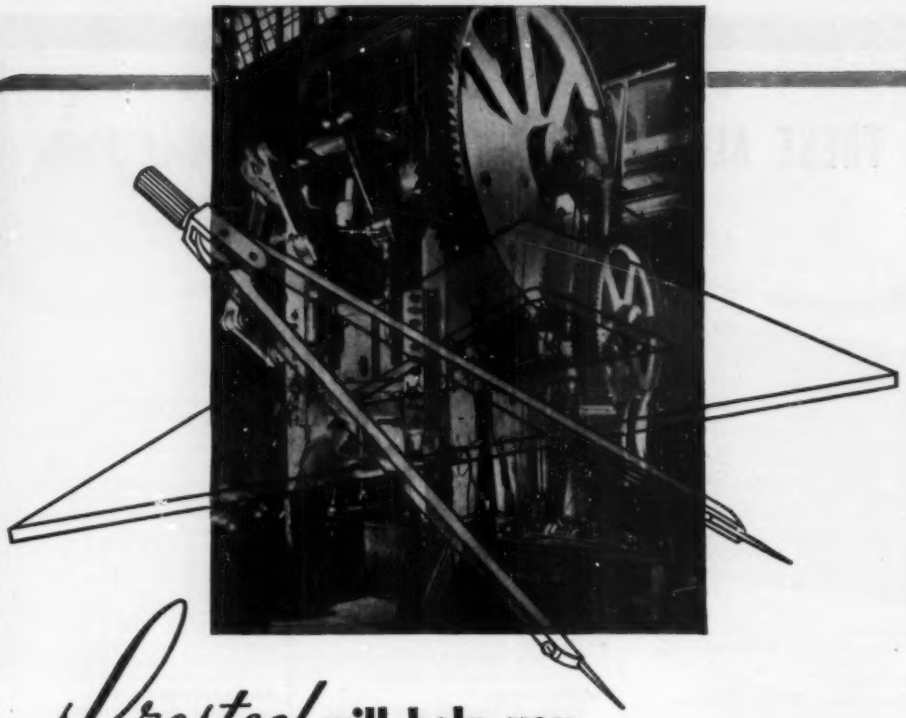
**WISCONSIN**
Milwaukee—735 N. Water Street
Phone Marquette 8-0185

**DISTRICT OF COLUMBIA**
Washington—1200 Ring Bldg.
Phone District 9400

# ALCOA ALUMINUM

INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

ALCOA ALUMINUM ®



# *Presteel* will help you RE-DESIGN to meet COMPETITION

The manufacturing cost of every metal component part in your product is important. It directly affects your profits. That's why Presteel is constantly re-designing parts for stamping that formerly were fashioned by a more expensive method. Time after time, Presteel stamping engineers have, among other things...

- Reduced the cost per piece
- Reduced production time
- Reduced the number of operations per piece
- Increased part efficiency.

Presteel has the design experience, the expert crattsmanship and the modern plant facilities to help you. Let your nearest Presteel representative talk with you about your component part production. The chances are he will be able to help you save money.

Representatives in DETROIT • BUFFALO
CANTON, OHIO • CHICAGO • DENVER
ALEXANDRIA, VA.

FORT WORTH • INDIANAPOLIS • LOS ANGELES
NEW YORK • PHILADELPHIA • SYRACUSE
TORONTO, CANADA

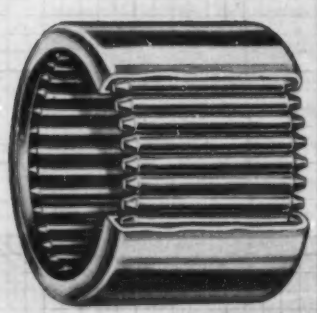
**WORCESTER PRESSED STEEL CO.**

703 BARBER AVENUE • WORCESTER 6, MASS.

ALLOY STEEL AND OTHER METALS COLD FASHIONED SINCE 1883

# more power to the prop
# in Kiekhaefer MERCURY motors

## through TORRINGTON NEEDLE BEARINGS



With maximum efficiency and minimum wear, Torrington Needle Bearings help roll 25 horsepower from the power head to the propeller in the Kiekhaefer MERCURY "Thunderbolt."

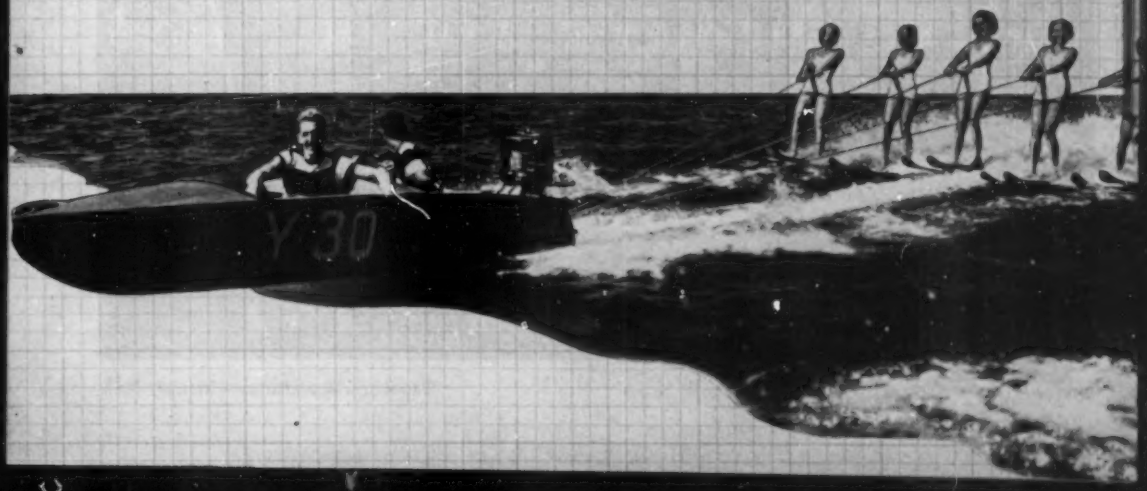
Anti-friction ease of operation all along the line is secured through the use of compact Needle Bearings on wristpins, crankpins, crank shaft and drive shaft. These high-capacity bearings help maintain precision and smoothness of motor performance under continual grueling operation.

Power output and service life of your product may be increased by the application of Torrington Needle Bearings. Our engineers will be glad to help you.

**THE TORRINGTON COMPANY**
Torrington, Conn. • South Bend 21, Ind.
District Offices and Distributors in Principal Cities of United States and Canada

## TORRINGTON *NEEDLE* BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS



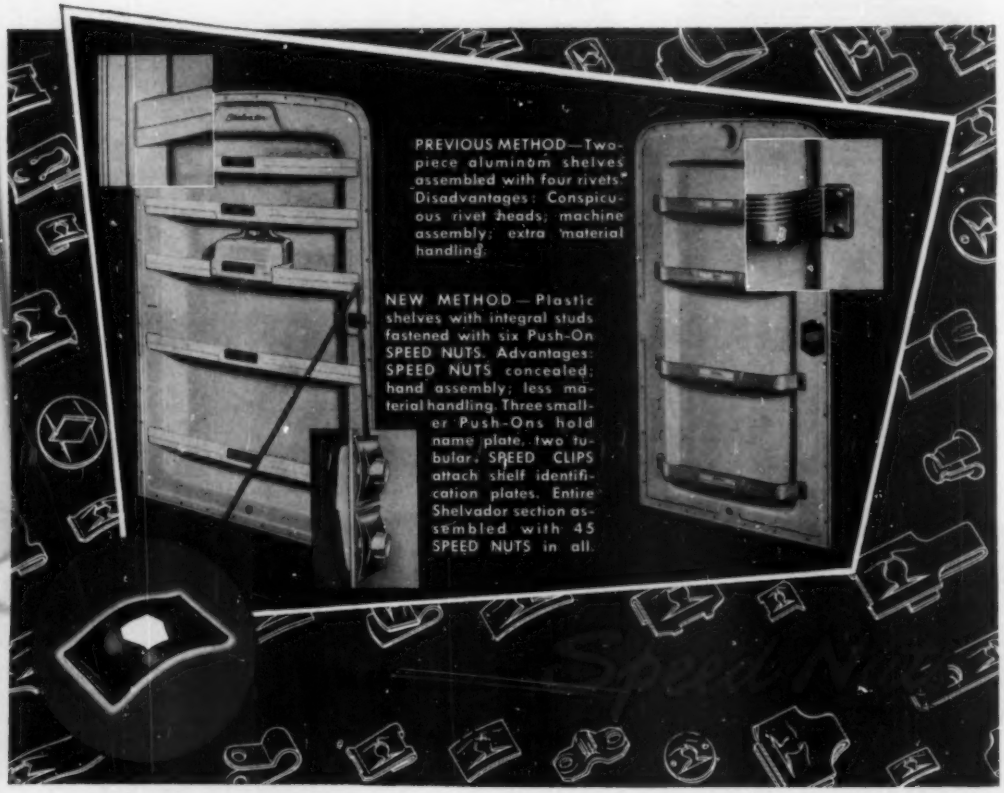
# How ~~CROSLEY~~ "Traded-In" *Speed Nut Savings* for Better Shelvador® Design

The 1950 Shelvador has been dressed up for even greater "buy-appeal" in 1950.

Crosley Division of AVCO Manufacturing Corporation has replaced riveted aluminum shelves with streamlined, gleaming plastic attached with Push-On SPEED NUTS—at no extra cost!

The assembly is now done by hand rather than machine, and the higher unit cost of the improved shelves is completely offset by a *49 percent SPEED NUT savings.*

You, too, can capitalize on savings from SPEED NUT brand fasteners. Ask your Tinnerman representative for details. Also write for booklet, "SPEED NUT Savings Stories". Tinnerman Products, Inc., 2040 Fulton Road, Cleveland 13, O. In Canada: Dominion Fasteners Limited, Hamilton.


PREVIOUS METHOD—Two-piece aluminum shelves assembled with four rivets. Disadvantages: Conspicuous rivet heads; machine assembly; extra material handling.
NEW METHOD—Plastic shelves with integral studs fastened with six Push-On SPEED NUTS. Advantages: SPEED NUTS concealed; hand assembly; less material handling. Three smaller Push-Ons hold name plate, two tubular. SPEED CLIPS attach shelf identification plates. Entire Shelvador section assembled with 45 SPEED NUTS in all.

# Professional Degrees Weaken With Age

FULL OF ENERGY, AMBITION AND ENTHUSIAM the new college graduate leaves the campus with his degree. Instinctively he knows that the XYZ Company gave him the job he has primarily because of that degree.

Only too often the college alumnus keeps on thinking about the wonders of his degree, its capacity to open doors, its great influence in seeking promotion and its cash value as reflected in the pay check.

Soon his first decade of industrial experience has passed. Slowly it dawns upon the college graduate that his business contacts no longer seem to be much interested in whether or not he has a college degree. The spotlight searching for the men to be promoted seems to skip over the question of professional degrees. The major emphasis is placed upon the man's accomplishments during his professional career. What is his standing? Is he capable of holding a responsible position?

It is highly significant that the stated requirements for member grade in the Society of Automotive Engineers makes no mention of a college degree. But the requirements, as set forth in the bylaws of the society, state in considerable detail what abilities and experiences must be possessed by the applicant.

Naturally and properly, a company will favor recent or new college graduates when seeking men to train for positions of responsibility. The college graduate presumably has a good foundation on which to build. However, after this man starts his business career it depends entirely upon him whether or not he builds and develops.

The records of industry clearly show that too many college graduates seek the easy road. They labor under the delusion that their precious degree will always keep them in a favored class. They try by various means to dodge the hard knocks and sacrifices that must be endured in getting the required training and experience to fit them for positions of responsibility.

There are innumerable men holding top positions in the engineering profession who have no college education. Quite a few of the outstanding engineers in the automotive industry, some of them holding the title of Vice President in Charge of Engineering, are not college graduates, nor are they "favored sons". They competed with college graduates in their advancement through the ranks and earned their promotions through accomplishments.

All of which proves that there is no substitute for hard work, practical experience, and ambition. Whatever may be the initial advantage of a college degree, it grows weak with age and soon vanishes.

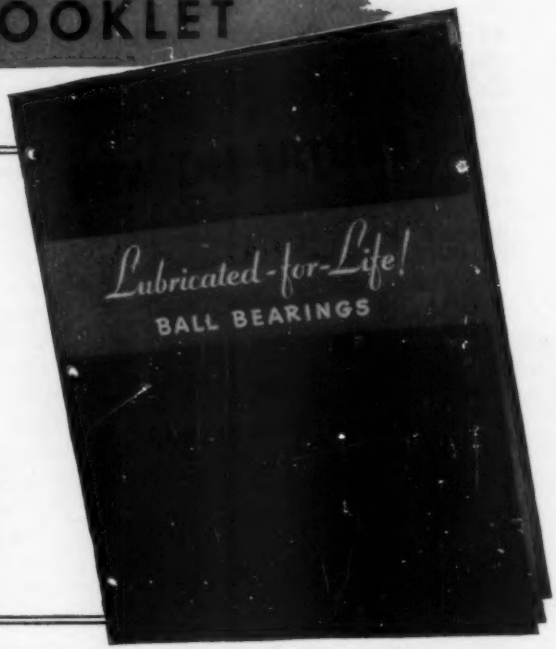
When the president of a university confers a degree, it is customary for him to close with the words, ". . . . . I grant you the degree of ————————,—, with all the rights and privileges pertaining thereto." What are those rights and privileges? They are merely the privilege of accepting a job and the right to put into it all the energy, hard work and diligence that you possess.

G. F. Rodenbolt

# For anyone interested in

# Conveyor Systems

## ... FREE BOOKLET




**Authoritative**
•
**Documented**
•
**Illustrated**
•
**Dimensions and Capacity Tables**

**MORE THAN** any other single invention perhaps, the mechanized conveyor system lifts the load off man's back and puts it on the machine.

It is a typically American invention, and it represents a typically American way of getting things done.

By originating and developing ball bearings which are lubricated-for-life and are sealed to keep dirt out, New Departure made a contribution of major importance to the modern conveyor system.

Proved in installations operating under rugged conditions, in temperatures from below zero to desert heat, and exposed to dust and dirt . . . carriers developed around these lubricated-for-life conveyor bearings are giving years of service without any cost for greasing.

The story of New Departure Conveyor Bearings and the services that go with them is told in a new booklet, illustrated above.

If you design or manufacture or use conveyor systems, you will find it interesting and helpful reading. Mailed promptly, to requests on business letterheads.

*Nothing Rolls Like a Ball . . .*
**NEW DEPARTURE**
**BALL BEARINGS**

90

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

*Kelvinator Div., Nash-Kelvinator Corp.*

**Large injection molding machines make possible economical production of large polystyrene refrigerator parts. Freezing compartment doors are being removed from two-cavity die in 40 oz press.**

SANFORD E. GLICK
Plastics Division,
Monsanto Chemical Company

## Low Cost and Valuable Properties Account for Increasing Use of

# STYRENE PLASTICS

**Formerly thought of as a "novelty" material, polystyrene is finding wide acceptance because of its excellent dimensional stability and ease of fabrication. Modified styrenes for special needs are available.**

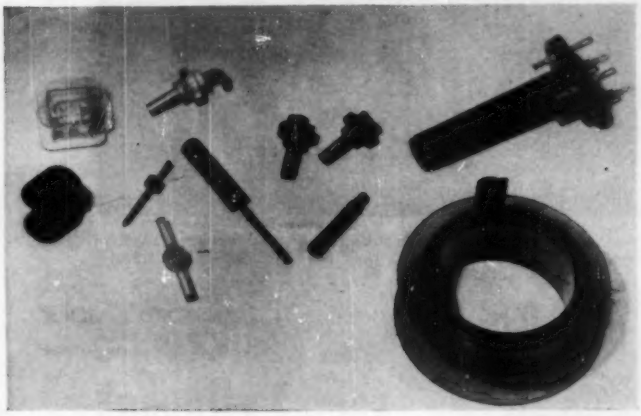
FIRST USED IN THE NOVELTY FIELD primarily because of its low cost (Table I), polystyrene is gaining increasing importance in industrial applications, including refrigeration, electrical, automotive and household appliances. Properties of polystyrene which stimulate this "industrial trend" include: Excellent dimensional stability; low moisture absorption; low specific gravity; uniform physical properties; non-retention of odors; resistance to attack by a wide range of foodstuffs and chemicals; and ease of moldability.

Since plastics are organic compounds, they inherently have a certain amount of instability of one type or another. Types of instability include: (a) Zero stress dimensional stability—the effect of humidity, drying and cycling when no load is applied; (b) heat distortion temperature; (c) cold flow; (d) effect of temperature on physical properties; (e) water absorption; (f) volatilization of compound and plasticizers; and (g) presence of internal strain.

ZERO STRESS DIMENSIONAL STABILITY. In selecting a plastic for an engineering application, its dimensional stability when no stress is applied is of prime importance. Table II shows that polystyrene has the best zero-stress di-

**Table I—Relative Cost of Various Plastic Molding Materials (based on weight and volume)**

| Plastic | Dollars per lb | Cents per 4 oz shot | Density lb/cu ft | Dollars per cu ft |
|---|---|---|---|---|
| THERMOPLASTIC MATERIALS | | | | |
| Polystyrene (clear) | 0.255 | 6.38 | 66.2 | 16.88 |
| Polystyrene (colored) | 0.315 | 7.88 | 66.2 | 20.85 |
| Polyethylene | 0.48 | 12.00 | 57.8 | 27.74 |
| Cellulose acetate | 0.35 | 8.75 | 82.4 | 28.84 |
| Polyvinyl chloride | 0.43 | 10.75 | 82.4 | 35.43 |
| Ethyl cellulose | 0.58 | 14.50 | 71.1 | 41.24 |
| Cellulose acetate-butyrate | 0.54 | 13.50 | 79.8 | 43.09 |
| Methyl methacrylate | 0.70 | 17.50 | 73.7 | 51.59 |
| Nylon | 1.60 | 40.00 | 71.1 | 113.76 |
| THERMOSETTING MATERIALS | | | | |
| Phenolics (avg. general purpose) | 0.165 | 4.13 | 86.1 | 14.21 |
| Ureas (avg. cellulose filled) | 0.31 | 7.75 | 93.6 | 29.02 |
| Melamines (avg. cellulose filled) | 0.50 | 12.50 | 91.8 | 45.90 |



**ELECTRICAL PARTS** molded of a heat resistant styrene copolymer (Cerex), a rigid thermoplastic, which has a heat distortion temperature of 226-234 F. These parts include coil forms, coaxial cable plugs and other electrical and high frequency insulation.

**Table II—Linear Dimensional Change of Molded Plastic Disks (in./in.)**

| Material | Test Conditions | | |
|---|---|---|---|
| | 5 days at 120 F dry | 5 days at 120 F, 86% R. H. | 5 cycles of 16 hr at 120 F and 86% R. H. plus 7 hr at 160 F |
| Polystyrene | −0.0002 | ..... | −0.0002 |
| Methyl Methacrylate (general purpose) | −0.0003 | +0.0020 | +0.0009 |
| Mica Filled Phenolic | −0.0005 | −0.0005 | −0.0005 |
| General Purpose Phenolic | −0.0008 | +0.0005 | −0.0005 |
| Urea Formaldehyde | −0.0060 | +0.0030 | +0.0010 |
| Mineral Filled Melamine | −0.0010 | +0.0010 | −0.0007 |
| Cellulose Filled Melamine | −0.0080 | +0.0042 | −0.0003 |
| Cellulose Acetate-Butyrate (H4 flow) | −0.0014 | +0.0042 | −0.002 |
| Cellulose Acetate (MH flow) | −0.009 | +0.010 | ..... |
| Polyvinyl Chloride-Acetate | +0.0006 | +0.0010 | −0.0006 |

R. Burns, *ASTM Bulletin*, May 1945, pp. 27-30.

mensional stability, under the three test conditions given, of all the thermoplastic or thermosetting materials listed. This property explains the advantage of using polystyrene in such applications as boxes, housings, refrigerator parts, and other parts of large projected area, where no warpage can be tolerated. However, the importance of operating temperatures should not be overlooked. Polystyrene, being a thermoplastic material, will distort when excessive temperatures are reached. Table II applies only to temperatures below the distortion point.

HEAT DISTORTION TEMPERATURE. The maximum operating temperature of molded polystyrene parts depends on the design of the piece, sustained load, and the presence of strain in the molded piece. Shown in Table III is a comparison of different thermoplastic materials for heat distortion, obtained by the procedure in ASTM D 648-45T. This property is also demonstrated by measurements of compressive deformation caused by temperature; the set of curves at the top of the following page, based on ASTM D621-45T, shows the performance of various thermoplastic materials when subjected to a load.

Industrial products molded of polystyrene, such as radio cabinets, camera cases, automotive parts, and electrical components have been known to withstand intermittent temperatures as high as 200 F without distortion, if the molded pieces are relatively free of strain and the proper heat resistant formulation of polystyrene is used. The usual maximum safe operating temperature for general purpose styrene molded parts is 170 F; but even 170 F may be too high for large stresses.

**Table III—Heat Distortion Temperatures of Thermoplastic Materials**

| Material | Temp. F |
|---|---|
| General Purpose Polystyrene | 175–190 |
| Heat Resistant Polystyrene | 203–230 |
| Cellulosic plastics | 115–225 |
| Acrylic plastics | 150–210 |
| Vinyl chloride and vinyl chloride-acetate copolymers | 142–153 |

*Technical Data on Plastics*, Plastics Materials Manufacturers Association, May, 1948

COLD FLOW. A practical definition of cold flow is a change of dimensions caused by sustained application of a load that stresses the material beyond

the elastic limit at a temperature below the heat distortion point. The series of curves presented in the section on heat distortion temperature is also somewhat indicative of cold flow.

A test of cold flow is to measure the percent change in thickness of a ½ in. cube placed between parallel plates, under a constant pressure of 4,000 psi at 120 F for 24 hr. The following table, based on the results of scattered investigations, is a rough comparison of cold flow of various plastics:

| Material | Cold Flow, percent |
|---|---|
| Heat Resistant Polystyrene | 0.36 |
| Phenol-Formaldehyde | 0.4 |
| Acryiics | 0.5 |
| General Purpose Polystyrene | 0.6 |
| Urea—Formaldehyde* | 0.4–7.0 |
| Polyvinyl Chloride* | 1.0–8 |
| Cellulose Acetate* | 2.0–10.0 |
| Cast Phenol-Formaldehyde | 10.0 |
| Hard Rubber* | 0.5–20 |

*Depending on formulation.

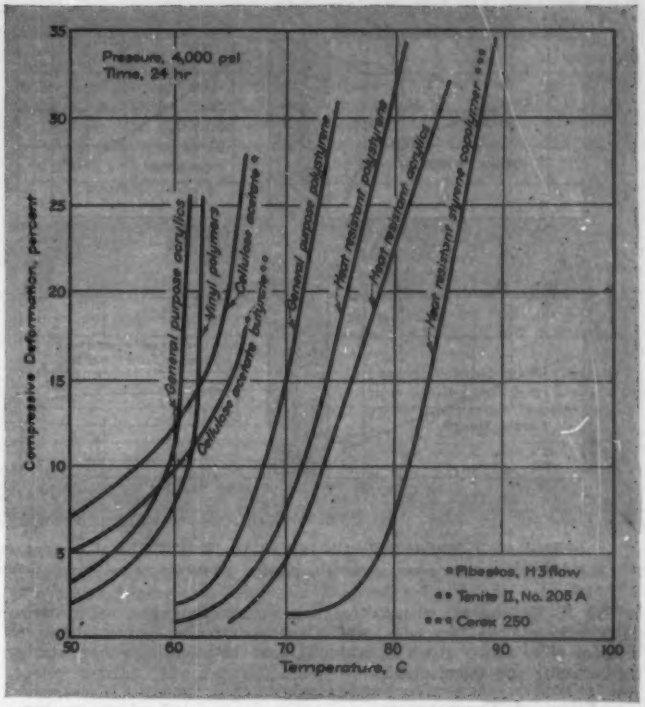
The curves at the bottom of this page show that a heat resistant polystyrene formulation has about 2/3 the cold flow of a Grade L phenolic laminate, under the stated conditions.

FLAMMABILITY. In such applications as cord plug sets, fluorescent lighting fixture end sockets, wall plates, and radio cabinets, the question of inflammability often arises. Table IV presents the ignition temperatures of various plastic materials, both in the presence and absence of the flame. Polystyrene must be heated to 910 F in the absence of a flame before self-ignition occurs. In a flame, polystyrene ignites

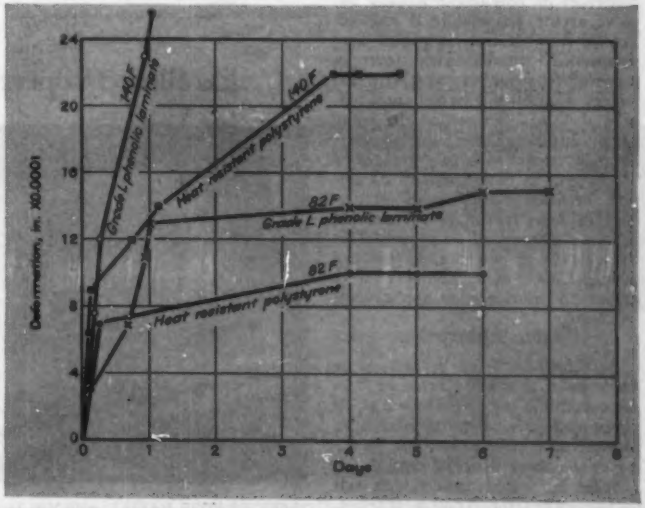
**Table IV—Ignition Temperatures of Plastic Materials**

| Plastics | Ignition Temperature, F | |
|---|---|---|
| | With Igniter Flame | By Self Ignition |
| Phenolic paper laminate | 644 | 968 |
| Phenolic cotton fabric laminate | 642 | 918 |
| Phenolic asbestos paper laminate | 720 | 932 |
| Melamine mineral filler | 898 | 1,130 |
| Polystyrene, compression molded | 653 | 910 |
| Vinyl chloride-acetate clear | 680 | 1,112 |
| Cellulose acetate | 580 | 842 |
| Methyl methacrylate | 574 | 860 |
| Cellulose nitrate | 291 | 291 |

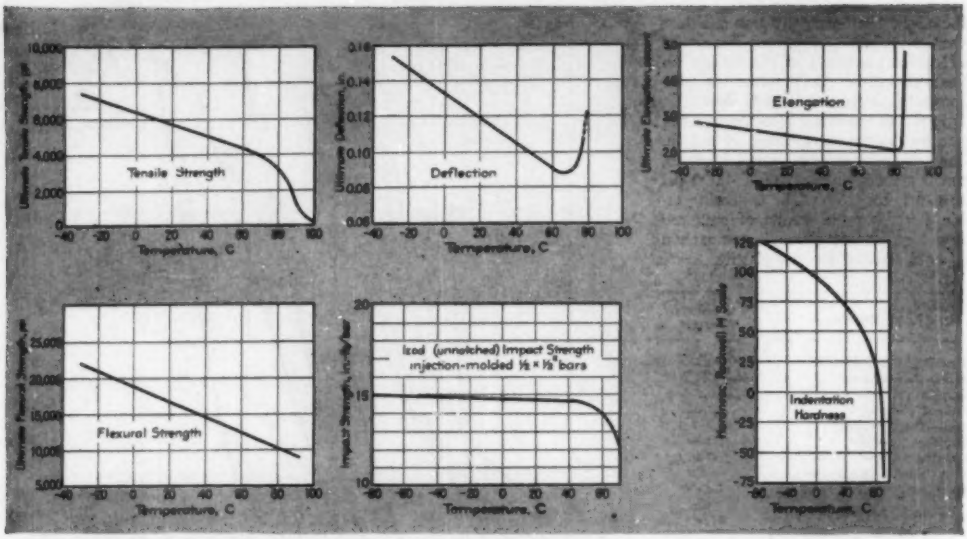
N. P. Setchkin, *ASTM Bulletin*, March 1948, pp. 66-69




**MAXIMUM OPERATING TEMPERATURES** of molded plastics depend on design and sustained load. These curves compare the effect of temperature on compressive deformation for various plastic materials. Although the curves are a measure of "safe" temperatures, these should be modified by internal strain and expected load.




**COLD FLOW COMPARISON** of a heat resistant polystyrene and Grade L phenolic laminate. In this test reduction in height of ½ in. cubes of each material, loaded with 800 lb at 82 and 140 F, were measured at intervals. Laminate went "off curve" after 1 day at 140 F. (Unpublished report of International Business Machines Corp.)




**EFFECT OF TEMPERATURE ON PHYSICAL PROPERTIES** of injection molded general purpose polystyrene. Unlike most other plastic materials, physical properties of polystyrene improve as the temperature is reduced.

at 653 F. Ignition temperatures for polystyrene compare favorably with those of other plastic materials, both thermosetting and thermoplastic.

## Effect of Temperature

Most plastic materials become increasingly brittle at lower temperatures. From the accompanying series of curves, it can be seen that physical properties of polystyrene actually improve as the temperature is reduced. Tensile strength and elongation were determined simultaneously over a range of temperatures using injection molded dumbell-shaped test specimens of ¼ x ¼ in. cross section. In going from room temperature to 0 F there is an improvement in tensile strength of 30 percent, in elongation of 20 percent, in flexural strength of 30 percent, in deflection of 40 percent and in impact strength of 20 percent. This characteristic is responsible for the wide acceptance of polystyrene in automotive and refrigeration applications.

## Water Absorption

As shown in Table V, polystyrene has a water absorption value of 0.04 percent; this is among the lowest of all plastic materials. Parts molded from polystyrene exhibit no warping, swelling or shrinkage when in water.

When polystyrene molded with wall thicknesses of 0.040-0.080 in. is tested, its resistance to moisture vapor transmission is excellent. A comparison of polystyrene containers and moisture proof cellophane was made by testing both at room temperatures and at −25 C, gave the following average results:

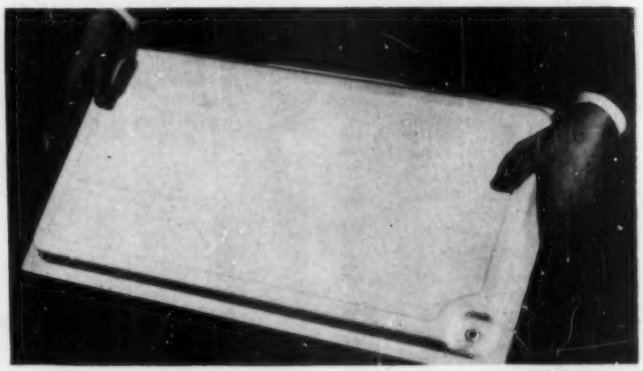
| Material | Rate of Moisture Vapor Transmission (g per 100 sq in. per day) |
|---|---|
| Polystyrene | 0.044 |
| Cellophane | 1.01 |

It is suggested that polystyrene containers be used for the shipping and storage of machine elements and other parts requiring constant dimensions.

Polystyrene has excellent resistance to alcohol, acids and alkalies. Most foods do not attack polystyrene. However, it is somewhat soluble in aromatic and chlorinated hydrocarbons.

A number of plastic materials, either through volatilization of plasticizers or further polymerization after molding, shrink with age. Since polystyrene contains no plasticizers and no polymeriz-

## Excellent Properties at Low Temperature



**REFRIGERATOR BAFFLE ASSEMBLY,** which separates freezing section from food storage compartment, is molded of polystyrene and filled with glass fiber insulation. The assembly not only meets the required standards of lightness, insulation and strength, but does not rust or chip and costs less to produce than the old type.

**Table V—Water Absorption of Plastic Materials**

| Material | Percent water absorbed After 24 hr immersion |
|---|---|
| Polystyrene | 0.04 |
| Urea-Formaldehyde | 0.4–0.8 |
| Cellulosics | 1.1–5.9 |
| Phenol-Formaldehyde | 0.3–1.7 |
| Vinyls | 0.07–0.08 |
| Melamines | 0.1–1.3 |

*Technical Data on Plastics*, Plastics Materials Manufacturers Association, May 1948

ation after molding occurs, and because of its low moisture absorption, dimensions of a molded polystyrene part will be maintained indefinitely.

## Applications

ELECTRICAL. When polystyrene was first introduced, one of its main fields of application was in the electrical industry. Its low power factor of 0.0002 and dielectric constant of 2.5 are responsible for polystyrene still being used in the electrical industry, where low dielectric loss is required. Electrical insulating applications of polystyrene include condensers, transformers, resistors, relays, capacitors and batteries, wall plug attachment caps, coil forms, receptacles, connectors, battery cases, switch plates and terminal blocks.

REFRIGERATION. Breaker strips, drip baffles, baskets, panels, doors, freezer lids, ice-cube separators, and other structural and functional parts are being molded from polystyrene. Ease of moldability, low cost, high dimensional stability and low heat conductivity contribute toward this increasing use. The following comparison shows that polystyrene conducts heat at a much slower rate than other molded plastics (from *Technical Data on Plastics*, Plastics Materials Manufacturers Association, May, 1948):

| Material | Thermal Conductivity ($10^{-4}$ cal/sec/sq cm/1 deg. C/cm) |
|---|---|
| Polystyrene | 1.8–2.0 |
| Cellulosics | 4–8 |
| Phenol-formaldehydes | 3–14 |
| Urea-formaldehydes | 7–10 |
| Melamines | 10–17 |
| Methyl methacrylate | 4–6 |

COST SAVINGS. Large refrigerator parts having projected areas of 364 sq in. have been produced, and serious consideration is being given to molding polystyrene inner door panels, having areas as large as 1,500 sq in., with new injection machines being developed.

A molded polystyrene battery case (Exide) permits a ratio of power to volume and weight greater than heretofore possible. The battery has a rating of 24 volts and is capable of producing 15 hp for three min; thus it offers more starting power with less space and weight than any other non-spill, lead-acid battery in production.

Parts of a dairy applicator, injection molded of polystyrene, represent a substantial saving over metal because of reduced machining, finishing and assembly steps. Polystyrene has added advantages of transparency and resistance to the action of non-aromatic antiseptics and other chemicals. Similar application of polystyrene is a one-piece molded milking machine head. Many hours of assembly time and extensive finishing operations were saved.

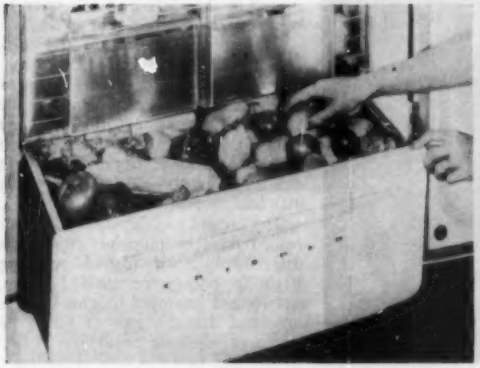
## New Types

HEAT RESISTANT POLYSTYRENE. A material developed to fill the need for a heat resistant polystyrene (Lustrex LX) also has improved impact and flexural strength (see table on page 159, Reference Book Sheet). However, this polystyrene formulation is not a "modified styrene"—that is, no chemical or physical addition has been made. The improved properties result from a change in the manufacturing process, which results in a change in the basic molecular configuration.

When used in interrupted frequency transformers for radios, standard polystyrene distorted so badly at 150 deg F that the cores could not be turned to permit tuning. The new compound will withstand 203 F before beginning to distort. Radio cabinets molded of standard polystyrene sag after exposure to 170 F for 2 hr. The same cabinet, molded of the heat resistant compound (see cover) withstands 190 F for 20 hr. Similar results were obtained on fluorescent light holders and battery cases.

By making the wall sections sufficiently thick, properly locating the gates and minimizing the strains, nearly any molded heat resistant poly-

## and High Humidity Make Styrene Plastics Ideal in Refrigerators



FRONT PANEL of 40-quart "crisper", on new line of Kelvinator refrigerators, is injection molded of white polystyrene. Above the crisper is a freshener zone with doors of clear polystyrene, inside which moist foods can be kept without covering.

*Kelvinator Div., Nash-Kelvinator Corporation*

LIDS ON NEW SIX-HOLE double row ice cream cabinet, injection molded of white modified styrene, resist "slamming" action. In such applications, styrene is used for its excellent dimensional stability in the presence of moisture and low temperatures.

styrene piece can be made to withstand boiling water for periods up to one hour. Section thicknesses of at least ⅛ in. are recommended when high resistance to heat is required.

MODIFIED STYRENES. Attempts to improve the heat resistance, toughness, light stability and other properties of polystyrene have resulted in a new series of "modified" styrenes, which are either a chemical modification of polystyrene—by means of copolymers or "cross-linking"—or a physical modification, in which a filler or chemical compound is present as a physical additive.

As shown in the table on page 157, the new series of modified styrenes offer a wide range of specialized properties. These compounds are somewhat more expensive than ordinary polystyrene, but this is usually justified in applications requiring special properties. The following are some of the best known of the modified styrenes:

*Cerex 250.* This heat-resistant copolymer is claimed to be the most heat-resistant material of this nature on the market.

*Styron 671.* A high heat resistant polystyrene modification, available in a wide range of colors.

*P-8.* This high heat-resisting, low shrinkage polystyrene can be molded in an unlimited range of colors, as readily as general-purpose polystyrene.

*Plexene M.* This material has improved weathering characteristics and better solvent resistance than regular polystyrene. Impact strength and heat-resistance is slightly better than that of polystyrene. Plexene M is finding some use for applications such as oil cups and transformer mounting parts.

*Plexene TA.* This "styrene type" molding compound has unusually high impact strength and excellent dimensional stability. It is available in a wide range of colors, and can be fabricated on conventional injection or extrusion equipment. It is used in electrical appliances, goggle frames, and housings of various types. Various formulations based on this material can be developed, so that desired specific properties are obtained.

*Styron 475.* This new, rigid, tough thermoplastic is quite similar to polystyrene. However, it has three to five times the impact strength of polystyrene, and its elongation is approximately ten times that of polystyrene. These two properties, coupled with good dimensional stability, low wtaer absorption, excellent electrical properties and chemical resistance, and a reasonable cost contribute toward its widespread application, especially in the refrigeration industry. Conventional fabricating techniques can be applied to this compound.

*Styron 637.* This new material has markedly improved light stability, compared with previous commercial polystyrenes. Although a regular grade of polystyrene would be reduced in light transmission from 87 to 66 percent after being exposed in an Atlas Fadometer for 500 hr, the light stable formulation only shows a slight decrease in light transmission, from 87½ to 86½ percent. These light transmission values were obtained at a wave length of 400 millimicrons. Because of its improved light stability, this material is eminently suitable for automotive parts, fluorescent lighting fixtures and other optical parts.

*Polyglas P.* This material, also designated Lustrex Q-3022, was developed jointly by Monsanto and the Radiation Laboratory at M.I.T. Its main advantage is that it possesses a thermal expansion approximating that of copper or brass. This permits it to be used around inserts of such metal without danger of cracking. In addition, Polyglas P has low electrical loss and can withstand high local heating.

*Latex-loaded mat.* This polystyrene glass mat composition, containing X-601 polystyrene resin, is received by the fabricator as a tough, stiff sheet. Developed jointly by Monsanto and the Owens-Corning Fiberglas Corporation, the material has merely to be cut, heated, and pressed to shape under very low pressures, and with molding cycles of 5 to 30 sec. Possible fields of application includes refrigerator door liners, inner doors and trays; housings for fans, radios, electric shavers, water coolers and dishwashers. Impact strength is 10 to 30 times that of regular molded polystyrene.

## Design Factors

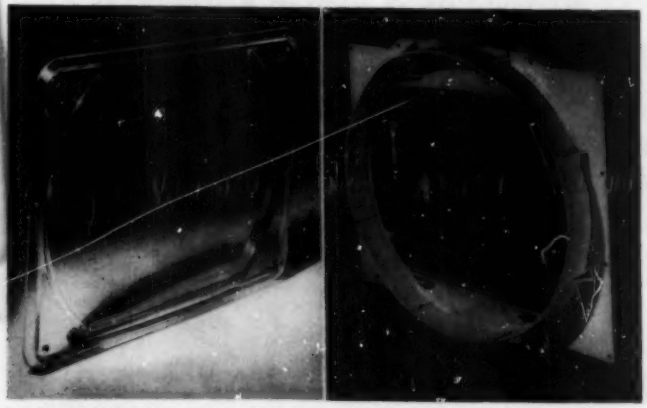
In assembling polystyrene parts, it is recommended that thread-cutting screws be used. Thread-forming screws alone often introduce a tendency to cracking. In designing the boss to hold the thread-cutting screw, it is suggested that the outside diameter be at least 1½ times the dia. of the screw.

Wherever possible, bosses should not be connected directly to surfaces of the molded piece. This will result in sink marks or require excessively long molding cycles to remove indentations. Frequently, it is possible to design a piece so that the boss is connected to the surface of the piece by means of a relatively thin section.

Close proximity of thin and thick sections should be avoided. Such conditions may result in excessive strains in the molded piece, unless they are annealed. Liberal use of fillets and radii should be made. Sharp corners should be avoided; they make molding difficult and concentrate stresses, which may lead to premature failure.

The recent introduction of controlled flow, or pinpoint gating, has contributed much toward reducing strain in polystyrene molded pieces, and toward improved toughness. It is suggested that this type of gating be employed wherever possible.

EDITOR'S NOTE: A chart listing physical, chemical and electrical properties of the styrene plastics is on page 159, Reference Book Sheet.



**TELEVISION MASKS and lenses are now molded of polystyrene, replacing acrylics and glass, because of low cost, dimensional stability and ease of molding. Lens is for 12½ in. set, and the mask is intended for a 16 in. television set. Previous masks were made from enameled metal or thermosetting materials which required painting.**

# NEW DRY CELLS

- Improved performance of conventional dry cells and characteristics of new types that have come from recent research allow greater flexibility.
- How new standard tests help in selecting the correct cell type for a specific industrial application.
- Specific improvements of new cells and conventional types include better resistance to high and low temperatures, longer storage life, lighter weight, more compact construction and desirable current characteristics.

**Table I—Standard Sizes of Leclanche Type Cylindrical Dry Cells**

| Cell designation* | Nominal dimensions** | | Approximate weight, lb | Principal uses |
|---|---|---|---|---|
| | Diameter, in. | Height, in. | | |
| AA | 17/32 | 1 7/8 | 0.033 | Flashlight, radio, misc. |
| A | 5/8 | 1 7/8 | 0.045 | Radio B battery |
| BF | 3/4 | 1 5/16 | 0.046 | Flashlight |
| BR | 3/4 | 1 1/2 | 0.052 | Radio |
| B | 3/4 | 2 1/8 | 0.077 | Radio B and C batteries |
| C | 15/16 | 1 13/16 | 0.10 | Flashlight |
| CL | 15/16 | 2 5/8 | 0.14 | Hearing aid |
| CD | 1 | 3 3/16 | 0.20 | Hearing aid |
| D | 1 1/4 | 2 1/4 | 0.22 | Flashlight, radio |
| E | 1 1/4 | 2 7/8 | 0.28 | Portable telephone |
| F | 1 1/4 | 3 7/16 | 0.35 | RR lantern, group, radio |
| G | 1 1/4 | 4 | 0.40 | Large B battery |
| J | 1 1/4 | 5 7/8 | 0.60 | Group battery |
| No. 6 | 2 1/2 | 6 | 2.2 | Telephone, ignition, general purpose |
| R | 17/32 | 1 5/16 | 0.023 | Radio |
| P | 17/32 | 1 | 0.017 | Radio |
| N | 7/16 | 1 1/16 | 0.013 | Radio |
| NS | 7/16 | 3/4 | 0.009 | Radio, hearing aid |
| U | 5/16 | 1/2 | 0.003 | Radio, hearing aid |

*These are standard types, and each one is produced by most of the recognized battery manufacturers. Cell letter is sometimes preceded by a number indicating the number of cells in series in the battery. When the number follows the cell letter it indicates the number of cells connected in parallel.

**These are nominal dimensions. The cell designations may apply to other dimensions and shapes of cells when grouped as batteries corresponding to the same standard size in volume or capacity rating.

WALTER J. HAMER
National Bureau of Standards

NO ONE TYPE OF DRY CELL is suitable for all purposes. Since dry cells are manufactured in different designs and materials, to meet the requirements of specific applications, performance of the various types differs greatly. Table I lists standard sizes of cylindrical dry cells with their principal uses.

Based on studies and recommendations of the American Electrochemical Society, the American Standards Association, the National Bureau of Standards, representatives of industry and several governmental departments, there are today 15 standard tests and two special tests dealing with radio "C" batteries and radio "A-B" jacks.

Schematic sketch of a typical cylindrical dry cell is shown in Fig. 1. A cylindrical can of zinc serves both as the negative terminal and the container of the cell, with a central carbon rod surrounded by a compressed bobbin of an intimate mixture of manganese dioxide and graphite or a carbon black. Saturated ammonium chloride is used as an electrolyte. The two electrodes are prevented from coming into contact by a non-conducting paste made of an aqueous gel of wheat flour and cornstarch.

Since the advent of the cylindrical dry cell other types have been developed. One type is constructed on the principles of the voltaic pile. The cells lend themselves only to battery construction; they are not used as individual units. The elements of these cells include a zinc plate coated on one side with a moisture-resistant, conductive layer of carbon paint. Next to the zinc surface is paper, and next to the paper is a depolarizing cake made of a mixture of acetylene black and manganese dioxide. The individual units are piled one on another and pressed together to form a battery, known as the "minimax" type. These cells are also known as the pile-construction type.

In another type, known as the "flat-cell construction" or layer-built, each unit is a complete cell constructed as a flat cake. The individual cells can be joined in parallel or series.

### Dry Cell Performance

A single cell has a nominal open-circuit voltage of approximately 1.5 volts; this varies somewhat with the type of manganese dioxide used by the manufacturer.

Ampere-hour capacities of conventional dry cells are roughly proportional to the volume of the cell. The smaller sizes AA to B are normally

**Table II—Dry Battery Tests and Performance Under Test Conditions**

| Type or use of dry battery | Test Conditions | | | | Average Performance of New Commercial Cells | |
|---|---|---|---|---|---|---|
| | Resistor for test ohms | Interval of continuous discharge | Interval of rest periods | Terminal voltage volts | Cell Size | Life*** |
| Radio "B" Battery | 1,250 | 4 hr | 16 hr* | 1.0-1.1 | D<br>F<br>G | 346 hr<br>572 hr<br>650 hr |
| Radio "B"Battery | 2,500 | 4 hr | 16 hr* | 1.0-1.1 | AA<br>A<br>BR<br>B<br>D | 84 hr<br>165 hr<br>206 hr<br>253 hr<br>626 hr |
| Radio "B" Battery | 5,000 | 4 hr | 16 hr* | 1.0-1.1 | U<br>NS<br>N | 7 hr<br>39 hr<br>116 hr |
| Railroad Lantern | 8 | 30 min every hr for 8 hr each day | 30 min and 16 hr | 0.9 | 4F | 46 hr |
| Flashlight Cells<br>General purpose No. 6 | 2 2/3 | 1 hr | alternate 6 and 16 hr | 0.85 | No.6 (General Purpose) | 77 hr |
| Industrial No. 6 | 2 2/3 | 1 hr | | 0.85 | Industrial No. 6 | 122 hr |
| General Purpose Cells** | 4 | 5 min | 24 hr | 0.75 | AA<br>C<br>D | 95 min<br>377 min<br>817 min |
| General Purpose Cells** | 2 1/4 | 5 min | 24 hr | 0.65 | D | 539 min |
| Light Industrial** | 4 | 4 min | 8 periods at hourly intervals each day with 16 hr intervening | 0.90 | D (Light Industiral) | 1,008 min |
| Heavy Industrial | 4 | 4 min | 8 periods every 15 min each day with 16 hr intervening | 0.90 | D | 839 min |

*Minimum.
**Generally for flashlights.
***After 6 months storage at normal temperatures, life of these cells decreases from 2 to 15 percent.

discharged intermittently at a rate less than 3 milliamperes and the larger ones at a rate of about 30 milliamperes. When discharged continuously at these rates, the cells give 0.1 to 20 amp-hr of service when discharged through a resistance of 4 ohms and give approximately 3 times as much service when discharged on a load of 40 ohms. The length of service a cell gives is a logarithmic function of the load resistance and the ratio of service to load is nearly a linear relation, the straight lines being parallel for cells of different sizes. A D-size cell discharged continuously through a resistance of 4 ohms to a cut-off voltage of 1.0 volt gives, on the average, 0.68 amp-hr capacity on a current drain of 20 milliamperes. On the same current drain to the same cut-off voltage the amp-hr capacity of the other sizes may be estimated in terms of the volume of the cells. The flash current of conventional cells range from about 4 to 40 amp for the smallest (AA) to the largest (No. 6) sizes.

Frequently cells are joined in series or in parallel to form electric batteries. Commercial batteries are most often assembled in groups of 2, 3, 4, 6, 15, 30 cells and so on, to produce batteries of 3, 4, 5, 6, 9, 22.5, 45, or more volts. Sometimes taps are provided so that a range of voltages can be obtained from one battery. Some batteries contain cells joined both in series and parallel connections. Thus, an almost unlimited number of batteries is possible.

### Tests

Life of a dry battery in operation depends on seven factors: (1) Current drain; (2) hours of use each day; (3) terminal voltage suitable for a specified purpose; (4) temperature of operation of the battery; (5) type of discharge, continuous or intermittent; (6) age of the battery; and (7) temperature at which the battery has been stored. It is extremely difficult to predict the life of any cell without knowing all of these factors. To estimate the life and performance of a cell for a specified purpose and for a desired operating schedule, standard tests and performance specifications are helpful to a consumer.

In Table II, standard tests for dry batteries for various purposes are listed. These tests are based on usual requirements. Performance characteristics of new commercial batteries are also given. These average performances, as found by the National Bureau of Standards, greatly exceed requirements in Federal specifications. These data apply to cells or batteries that are new or a few weeks old at the most. A hearing-aid battery made with D-size cells will give 60 hr of service when discharged through a resistance of 20 ohms for 12 hr with rest periods of 12 hr intervening to a terminal voltage of 1.0 volt. More hours of service would be obtained if the battery were discharged to a lower terminal voltage, but the hearing aid probably would not work on a lower potential difference. The life data given in Table II represent performance of the new conventional cells, and greatly exceed those of ten to twenty years ago.

Dry cells and batteries give decreased service with increased storage age. This is caused by chemical reactions and moisture changes that occur within the cell. Although these chemical reactions and moisture changes proceed at a slow rate in storage, the drier a cell becomes the poorer its operating characteristics. In general, if a dry cell does not receive abusive treatment, it can be expected to last for about two years. Small batteries deteriorate at a faster rate than larger batteries. Much research to improve the shelf life of dry cells is being carried out, with some success.

### Low and High Temperatures

Standard tests and performances listed in this article refer to normal temperatures. The usual type of dry cell becomes inoperative at – 20 C and "gases" at temperatures of 54 C.

Typical data for a range of temperatures are given in Table III. In recent years much work has been done to improve the characteristics of dry cells at both low and high temperatures; the results are promising.

Three different electrolytes have been proposed for low-temperature dry cells. These are methylamine hydrochloride, lithium chloride, and calcium chloride, each mixed with ammonium chloride or a mixture of ammonium and zinc chlorides. Additional improvements in cells of this type include a separator wall of viscous polyvinyl alcohol, methyl cellulose, or sodium carboxymethyl cellulose mixed with some starch. These cells are claimed to give at –30 C about 10 to 20 percent of the output of conventional type cells at normal temperatures.

The electrolyte for the lithium chloride cell consists of 15 percent lithium chloride, 10 percent zinc chloride, 8 percent ammonium chloride, and 65 percent water. These cells have the following characteristics (as given

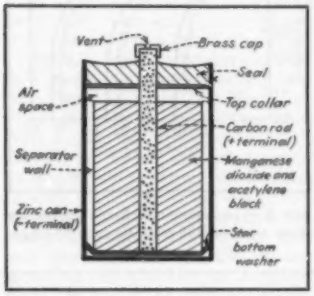



**Fig. 1**—Cross-section of a typical cylindrical (Leclanche type) dry cell.

by Milton E. Wilkie, *Trans Electrochem. Soc.* 90, 433, 1946):

*Heavy Drain:* Cells that give 1 to 10 hr of service at 21 C give about 10 percent of this output at –40 C.

*Medium Drain:* Cells that give 10 to 100 hr service at 21 C give about 15 percent of this capacity at –40 C.

*Light Drain:* Cells that give 100 or more hr of service at 21 C give about 20 percent of this capacity at –40 C. The flash current of D-size cells of this type at –40 C is 1.4 amp; yet conventional types give no appreciable current at –40 C—in fact they are inoperative at –40 C.

The formula for the calcium-zinc chlorides dry cell is quite critical. Equal concentrations of anhydrous calcium and zinc chlorides in a 9 percent solution of aqueous ammonium chloride appear to give the best results. On moderate drains, D-size cells discharging continuously through 16 ohms at –30 C, are reported to give 833 min of service to a terminal voltage of 0.75 volt per cell. However, for some unexplained reason, reproducible results are not always obtained. It is possible that the concentrations of the salts must be controlled within very fine limits. Better performance is obtained when the concentration of calcium chloride is increased, if an excessive amount of zinc chloride is not present. If excess zinc chloride forms at the zinc electrode as a result of local corrosion, unsatisfactory results can be expected.

At high temperatures conventional dry cells corrode at an increased rate, leading to an excessive drying out of the cell and decrease in electrical capacity. The drying out can be retarded by coating the cells within a thin layer of vinyl plastic permeable to hydrogen gas but not to moisture. If this membrane is not permeable to hydrogen gas, excessive pressures build up within the cell, which then bursts. When a D-size cell is stored for 6 months at 130 F without a vinyl plastic coating, only 170 min of service will be available in the light industrial flashlight test. If the cell is coated with the plastic, 420 to 520 min of service are obtained.

### New Cells

New dry cells now in commercial production are the air-depolarized "hearing-aid" cell, the RM mercuric oxide cell, and the Vidor Kalium dry cell. The latter two are similar in chemical constitution and differ only in mechanical design. The new air-depolarized type is lighter than the conventional type, and is stated to last longer, than the conventional types of equivalent weight. It is designed especially for electronic hearing-aid devices and utilizes air from the atmosphere for depolarizing action instead of chemical depolarizers. It is suited for services requiring low rates of current drain but functions less satisfactorily when subjected to high drains. This type of cell operates until the zinc is consumed.

The RM mercuric oxide dry cell is stated to give more hours of service per unit weight than the conventional dry cells and to have superior characteristics at high temperatures, making it suitable for tropical service.

Until the behavior of these newer cells in storage is ascertained final

**Table III—Effect of Temperature and Current Drain on Voltages of Conventional Dry Cells**

B-SIZE CELLS

| Temperature C | Open-Circuit Voltage volts | 2500-ohm Resistor volts | 100-ohm Resistor volts | 25-ohm Resistor volts | 4-ohm Resistor volts |
|---|---|---|---|---|---|
| 20 | 1.540 | 1.53 | 1.44 | 1.38 | 1.04 |
| 10 | 1.537 | 1.53 | 1.43 | 1.36 | 0.98 |
| 0 | 1.533 | 1.53 | 1.41 | 1.32 | 0.89 |
| –10 | 1.523 | 1.53 | 1.39 | 1.31 | 0.84 |
| –20 | 1.523 | 1.51 | 1.37 | 1.24 | 0.69 |
| –21 | 1.510 | 1.51 | 1.36 | 1.23 | 0.67 |
| –22 | 1.510 | 1.51 | 1.32 | 1.10 | 0.48 |
| –30 | 1.508 | 1.50 | 0.74 | 0.21 | 0.10 |
| –40 | 1.530 | 1.42 | 0.10 | .... | .... |
| –50 | 1.540 | 0.88 | .... | .... | .... |
| –60 | 1.540 | 0.15 | .... | .... | .... |
| –70 | 1.526 | 0.00 | .... | .... | .... |
| –80 | 1.51 | .... | .... | .... | .... |

D-SIZE CELLS

| Temperature C | Open-Circuit Voltage volts | Flash Current amp | % Current maintained | Terminal voltage at indicated drains, volts | | | |
|---|---|---|---|---|---|---|---|
| | | | | 20 ma | 50 ma | 100 ma | 140 ma |
| 25 | 1.644 | 6.6 | 100 | 1.639 | 1.628 | 1.607 | 1.599 |
| 20 | 1.643 | 6.1 | 92 | 1.637 | 1.624 | 1.603 | 1.591 |
| 10 | 1.641 | 5.2 | 79 | 1.634 | 1.620 | 1.592 | 1.579 |
| 0 | 1.640 | 4.2 | 64 | 1.631 | 1.614 | 1.581 | 1.568 |
| –10 | 1.639 | 3.1 | 47 | 1.627 | 1.605 | 1.564 | 1.537 |
| –20 | 1.630 | 1.0 | 15 | 1.61 | 1.59 | 1.54 | 1.52 |
| –30 | 1.610 | 0.1 | 1.5 | 1.49 | 1.28 | 0.96 | 0.86 |

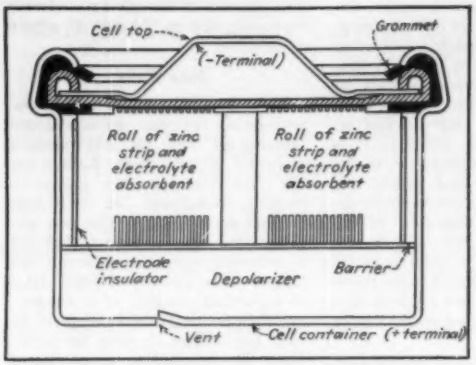



Fig. 2—Assembly details of the roll-anode type of RM mercuric oxide dry cell. Steel container serves as the positive terminal.

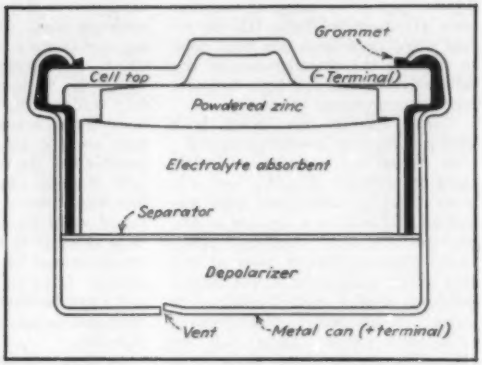



Fig. 3—Assembly of the pressed-anode type RM mercuric oxide dry cell. Anode is pressed from amalgamated zinc powder.

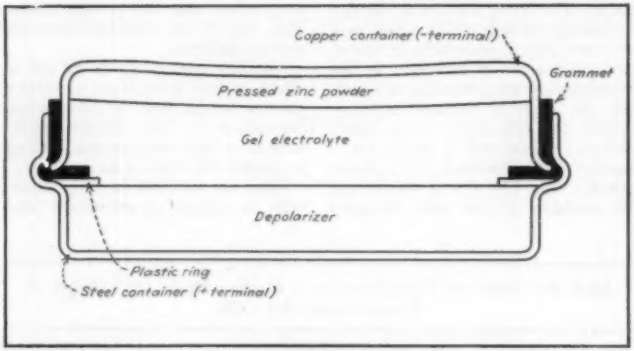



Fig. 4—Button-type of RM mercuric oxide dry cell uses gel instead of liquid electrolyte used in pressed-anode type. The type of crimp employed is also somewhat different.

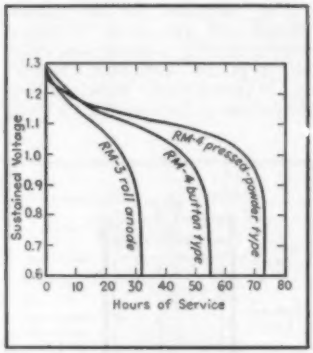



Fig. 5—Continuous discharge curves for three types of RM cells, through 60 ohms.

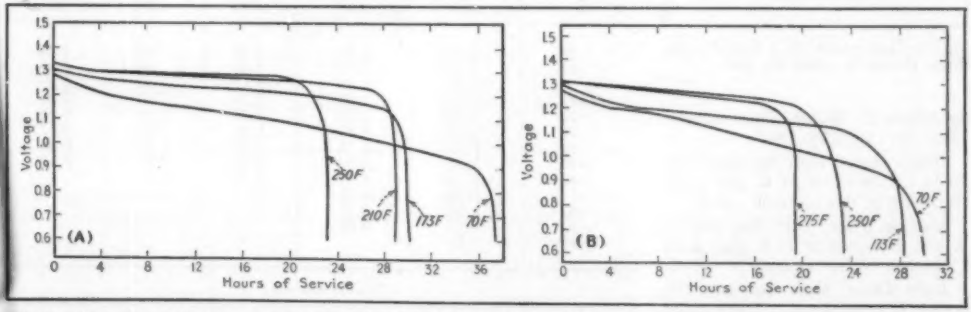



Fig. 6—Effect of operating temperature on capacity of *(A)* RM-1 and *(B)* RM-3 cells, discharged through 60 ohms continuously.

ratings of these cells must be deferred. However, data available at present indicate that these newer cells show great promise.

The RM mercuric oxide cell, known also as the Ruben-Mallory cell (hence the designation RM), is an alkaline cell utilizing an aqueous solution of potassium hydroxide and electrodes of zinc and of mercuric oxide mixed with 5 percent graphite. It has been used in walkie-talkies and mine detectors and is now being adapted to some hearing-aid devices. It is made in several forms; the most common are the roll-anode, pressed- or pellett-anode, and button types. The open-circuit voltage of this cell is 1.345 volts but can be varied between 1.343 and 1.368 volts by changes in the concentration of the electrolyte. The open-circuit voltage also varies with time. A cell having an initial open-circuit voltage of 1.368 volts exhibits a decrease in open-circuit voltage to 1.344 volts in one year.

A sketch of the roll-anode type is

shown in Fig. 2. The container is made of steel and serves as the positive terminal. Mercuric oxide, mixed with 5 percent graphite to increase the conductivity of the oxide, is pressed into a hard cake in the bottom of the steel container. The negative electrode consists of strips of zinc and paper in the form of a roll. The paper protrudes at one side and the zinc at the other side. The roll is placed so that the protruding paper faces the mercuric oxide-graphite cake, separating the two electrodes from each other. The roll is saturated with liquid electrolyte and is enclosed in a polystyrene or other plastic sleeve to insulate it from the steel can. The cell is completed with a copper top and neoprene grommet, crimped into the top of the steel container to contact the edge of the negative zinc electrode.

The pressed-anode type is shown in Fig. 3. It resembles the roll-anode type except for cell assembly. The pressed amalgamated zinc powder is in direct contact with an absorbent, saturated with liquid electrolyte. The button type, shown in Fig. 4, differs from the pressed-powder cell only in the type of crimp, and a gel electrolyte is used in place of a liquid electrolyte.

The RM cell is made commercially in a number of dimensions and cell types, listed in Table IV. The quantity of electricity theoretically available from a gram of depolarizer is 0.235 amp-hr. As the RM cell operates with an efficiency of 85 percent, the nominal capacity is 0.2 amp-hr per gm of depolarizer. Optimum current drain for maximum practical efficiency is 1.55 amp per sq decimeter. On normal drains the cell exhibits a flat discharge curve. In Fig. 5 the discharge curves are shown for three types of RM cells; all RM cells exhibit similar discharge curves. In Fig. 6 the effect of temperature on the capacity of RM cells is shown. The cells gas only slightly at the higher temperatures. On storage at 21, 45, and 55C, the cells retain respectively 88, 77, and 56 percent of their capacity after one year.

The Vidor Kalium cell, shown in Fig. 7, is designed on the same principles as conventional cells. These cells are made in a variety of dimensions. A 61 by 32.5 mm cell, when discharged continuously through a resistance of 5 ohms, has a working voltage of 1.15 volts for one day, which drops gradually to 1.0 during the next 10 to 11 hr, and to almost zero on an additional 1 to 2 hr discharge.

### Magnesium Cells

Within recent years, dry cells of conventional design but with magnesium instead of zinc electrodes have been studied (R. C. Kirk and A. B. Fry, *J. Electrochem. Soc.* 94, 277, 1948). These cells have characteristics similar to the conventional types but have a working voltage about 0.1 volt greater. The better magnesium cells are made with a negative electrode of magnesium-zinc alloy, a positive electrode of manganese dioxide mixed with acetylene black, and an electrolyte of alkali or alkaline bromides. Strontium bromide makes a good electrolyte. Usual pastewall separators are used. Ammonium chromate is added to the cell in small quantities to curtail local corrosion at the magnesium.

When D-size cells of the new type are intermittently discharged through 6.67 ohms for 4 min every 30 min during a 10 hr day for a 5 day week, they give 18.1 days of service to a terminal voltage of 0.935 volt, as compared with 15.1 days of service for zinc cells discharged under the same conditions. These cells have an initial open-circuit voltage of 2.04 volts but after 1 day of discharge have voltages only 0.1 volt above the conventional zinc dry cells. When magnesium cells are discharged continuously through 83.33 ohms to an end voltage of 1.13 volts they give 306 hr of service. Zinc cells give 230 hr under the same conditions. Magnesium dry cells have relatively good low-temperature characteristics; at —20 F they give 32 percent of their normal 70 F capacity. Although these cells are too new for conclusive results, the few that have been studied have shown no perforation of the magnesium can after 8 months storage at normal temperatures. Also, the cell properties do not seem to be altered during storage.

No one type of dry cell is suitable for all types of service. One type may be better for a certain type of service, yet is inadequate for an entirely different application. At the present time, extensive research is being performed to improve the characteristics of dry cells and to find new and different types. The next few years will see many changes in the battery field.

**Table IV—Types and Characteristics of RM Mercuric Oxide Dry Cells**

| Type No. | Diameter, in. | Height, in. | Volume, cu in. | Weight, grams | Flash Current, amp | Normal Current Drain, ma | Rated Capacity, amp-hr | Anode Type |
|---|---|---|---|---|---|---|---|---|
| R1 | 0.608 | 0.490 | 0.142 | 8.1 | 0.6 | 1–25 | 0.650 | roll |
| R2 | 0.824 | 0.518 | 0.276 | 15.7 | 1.0 | 25–40 | 1.40 | roll |
| R3 | 0.975 | 0.520 | 0.389 | 24.6 | 1.6 | 40–70 | 2.00 | roll |
| R4 | 1.190 | 0.541 | 0.602 | 38.1 | 2.0 | 40–90 | 3.400 | roll |
| RP3 | 0.975 | 0.650 | 0.389 | 24.6 | 1.1 | 25–50 | 2.00 | pressed |
| RP4 | 1.190 | 0.650 | 0.602 | 38.1 | 1.5 | 30–60 | 3.40 | pressed |
| RM-0 | 0.580 | 0.240 | 0.064 | 3.9 | 0.5 | 0.1–10 | 0.30 | pressed |

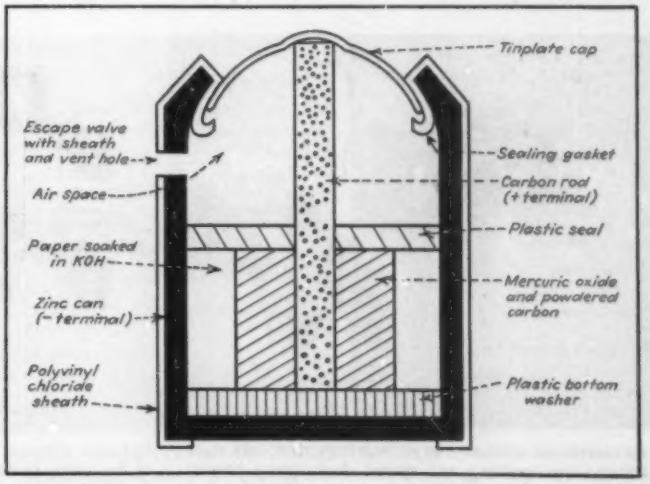
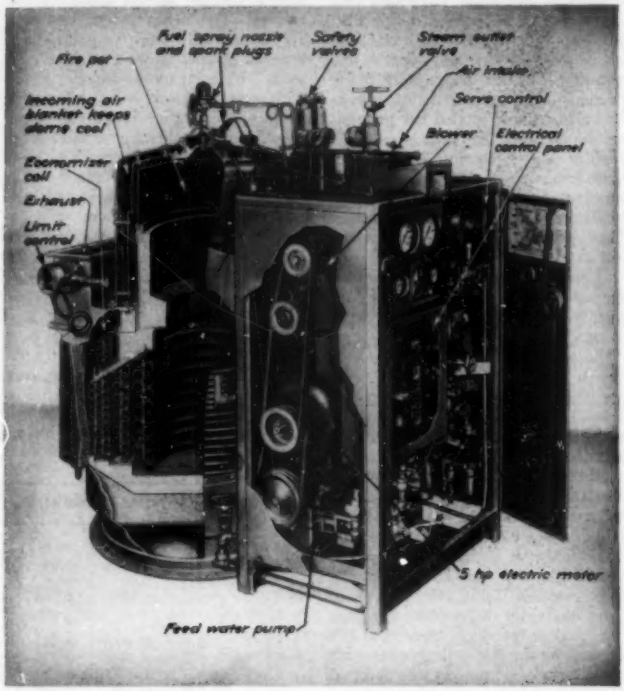


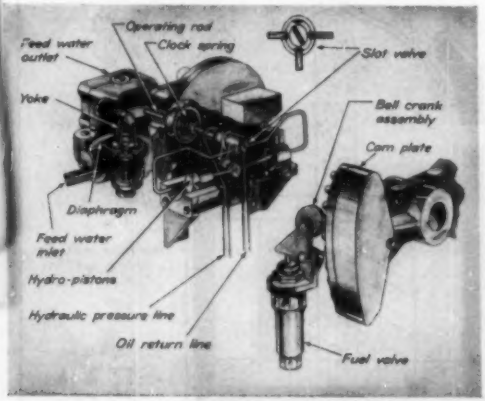

**Fig. 7—Cross-section of the Vidor Kalium dry cell, which is of European origin. Unlike RM cells, pressure-responsive vent is located at top of container.**

# Portable High Capacity Steam Unit

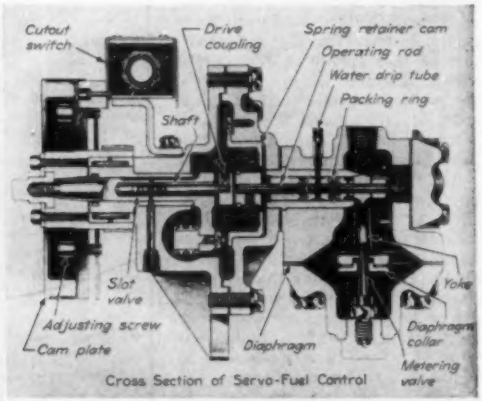
The Vapor-Clarkson Model OK 4625 steam generator is a portable, self-contained source of high pressure steam. Originally designed for heating diesel powered trains, the unit evaporates 3,000 lb of water per hr at pressures between 75 and 250 psi. Other models of similar design generate as much as 15,500 lb of steam at pressures up to 600 psi. Six jets of burning atomized diesel oil produce 1,000,000 Btu per cu ft of fire box. The generator is of water tube—rather than fire tube—design. Feature of the device is an extensive system of automatic controls. The Vapor Heating Corporation of Chicago says their units are also being used to supply equipment, such as pile drivers.

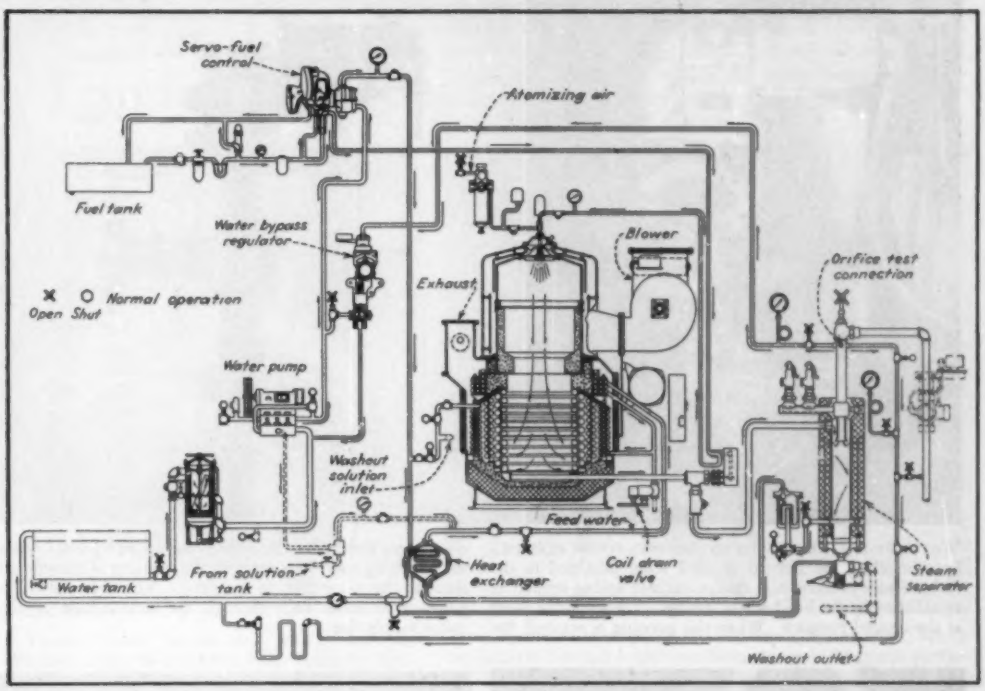



FROM A COLD START, THE GENERATOR DEVELOPS 200 PSI OF STEAM WITHIN 2 MIN. Hot gases wiping over the coils turn 6 gal of water into steam each minute under full fire. A single 5 hp electric motor drives all auxiliaries—water pump, fuel pump, blower and ignition system.

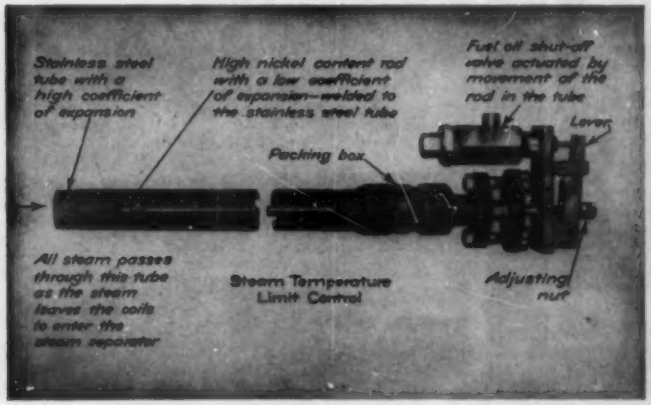



AS DIAPHRAGM DEFLECTS IN PROPORTION TO WATER FLOW, it turns the operating rod against clock spring pressure. At the same time, the slot valve turns within the shaft, aligning the valve slots with the shaft ports. Thus, hydraulic pressure is admitted to the pistons. Movement of the pistons causes the shaft and cam plate to rotate until the shaft ports move away from the valve slots, shutting off pressure from the pistons.

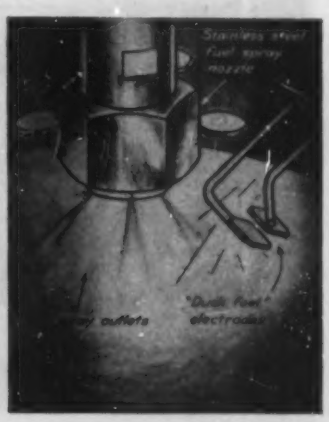





ALL WATER PUMPED INTO UNIT IS CONVERTED TO STEAM, with the exception of a small amount needed to carry the water treatment sludge. This extra water is removed by the steam separator and returned to the water supply tank. There is no water waste, an important consideration in portable units. The servo-fuel control regulates the intensity of the fire in accordance with feed water flow by means of 2 cams that vary fuel and air settings.


Stainless steel tube with a high coefficient of expansion
High nickel content rod with a low coefficient of expansion—welded to the stainless steel tube
Fuel oil shut-off valve actuated by movement of the rod in the tube
Lever
Packing box
All steam passes through this tube as the steam leaves the coils to enter the steam separator
Steam Temperature Limit Control
Adjusting nut

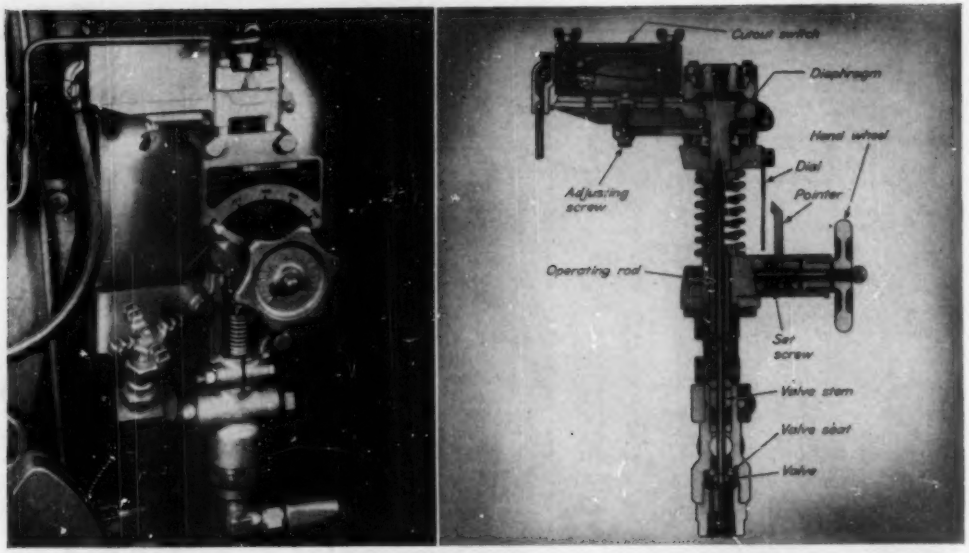
BIMETALLIC DEVICE GUARDS AGAINST EXCESSIVE STEAM TEMPERATURES should water supply lessen or fail altogether. At temperatures above 450 F, the flow of fuel is automatically cut off. The fire goes out but the water pump and blower fan continue to operate, thereby cooling the coils.



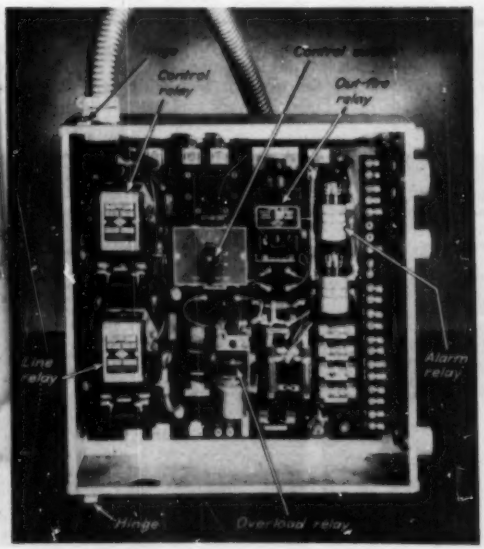

SIX SPRAY OUTLETS in the stainless steel burner gun are angled so flame hugs the sides of the combustion chamber. Electrode tips are flat.

(Continued on next page)

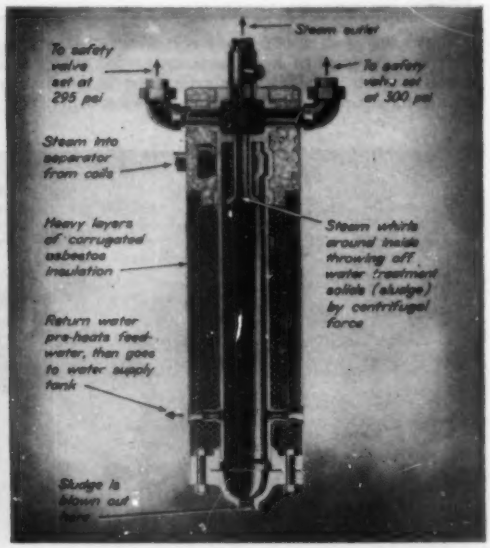
## Portable Steam Unit (continued)




WATER BY-PASS REGULATOR DETERMINES STEAM PRESSURE by controlling the amount of feed water admitted to the coils. Steam pressure acts against variable spring tension as established by the hand-wheel setting. The indicator is set at the desired pressure. When this pressure is reached, the diaphragm overcomes the spring tension and pushes down the operating rod. This downward movement is transmitted through the valve stem to the valve. The open valve by-passes feed water back through the suction side of the water supply line.



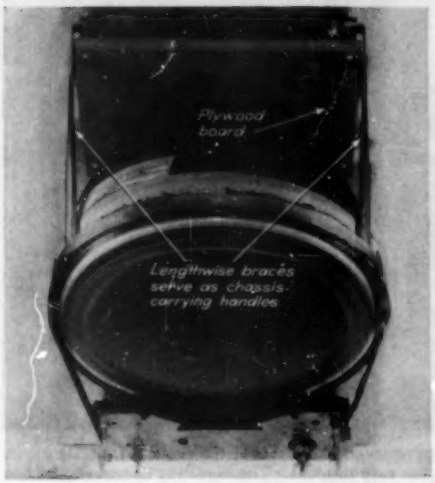

ELECTRICAL CONTROL PANEL IS HINGE MOUNTED. It can be swung out so that devices located behind the panel are accessible for servicing. Out fire relay operates if fuel does not ignite within 45 sec after control switch is cut in.


Steam outlet
To safety valve set at 295 psi
To safety valve set at 300 psi
Steam into separator from coils
Heavy layers of corrugated asbestos insulation
Steam whirls around inside throwing off water treatment solids (sludge) by centrifugal force
Return water pre-heats feed-water, then goes to water supply tank
Sludge is blown out here

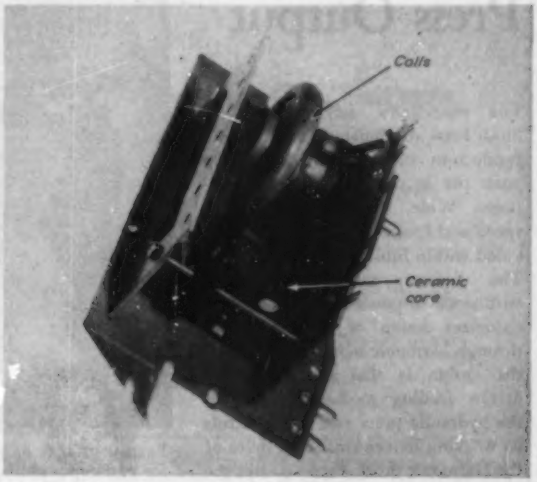
STEAM SEPARATOR INLET IS OFF-CENTER to give the steam a whirling motion as it enters. It performs two separating functions—water from steam and sludge from water. Steam pressure blows out the sludge when the valve is opened.

# Ceramic Core For TV Transformer

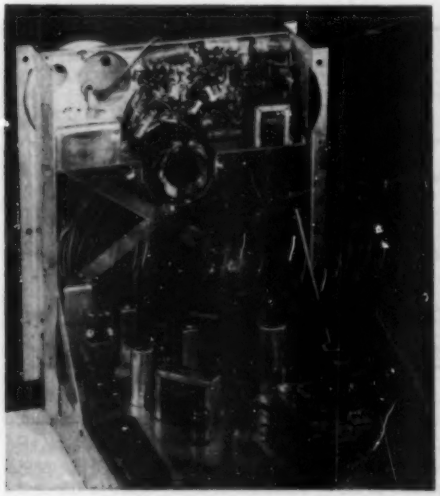
**Good mechanical design is evident in the new Sylvania television sets. The chassis has a steel superstructure that supports and protects the picture tube. So rigid is this structure that sets of all sizes are shipped with the picture tube in place. Other features are the compact chassis and convenient location of adjusting controls. Electronic engineers of Sylvania's Colonial Radio Div. in Buffalo are using magnetic ceramic material in their new deflection transformer.**



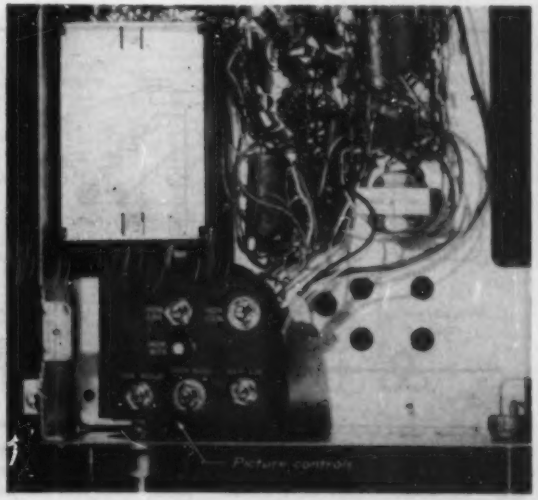

PLYWOOD BOARD SERVES AS A BRACE and shock absorber for the 16 in. picture tube. Adhesive tape—coated on both sides—bonds the tube periphery to the steel frame. Tube is installed at factory.




DEFLECTION TRANSFORMER HAS PRESSED CERAMIC CORE, which replaces the laminated steel core formerly used. Magnetic permeability and eddy current losses of new core are comparable to those of the old core which was higher in price.



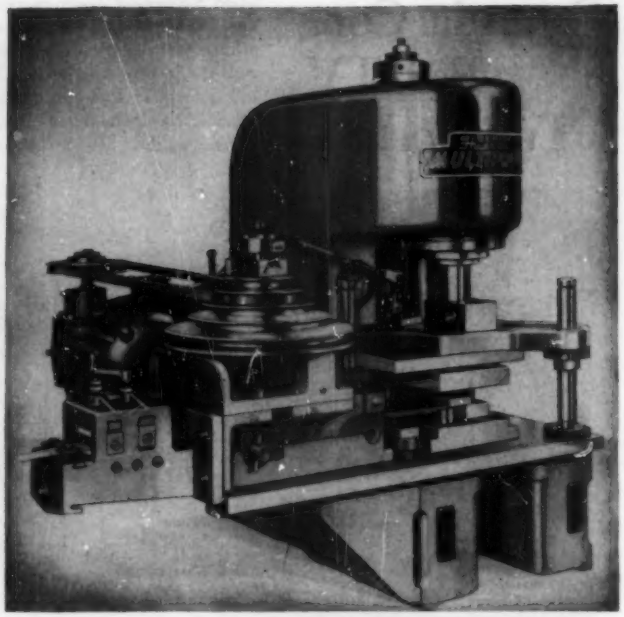
CHASSIS DEPTH IS MINIMIZED BY MOUNTING deflection and high voltage circuits on bridge across top of set. Bridge and its supports are part of superstructure.



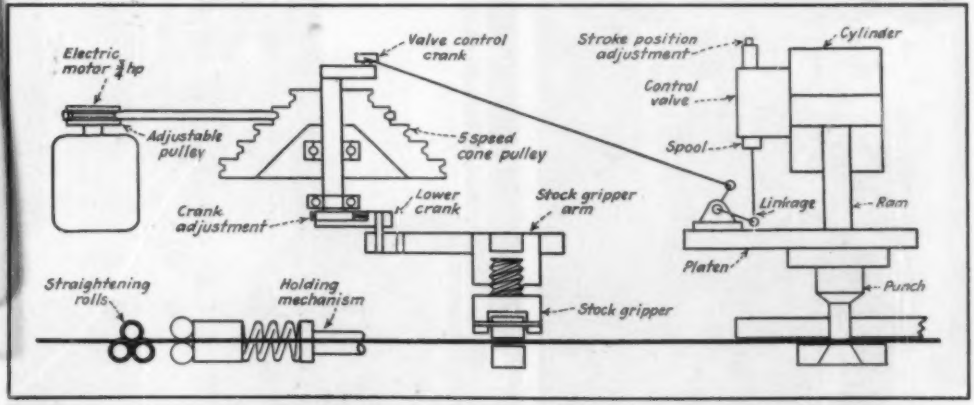

PICTURE CONTROLS have been relocated to the front of the chassis and are accessible through the bottom of the cabinet. Serviceman can observe picture while making adjustments.

# Power Feed Steps Up Oil Press Output

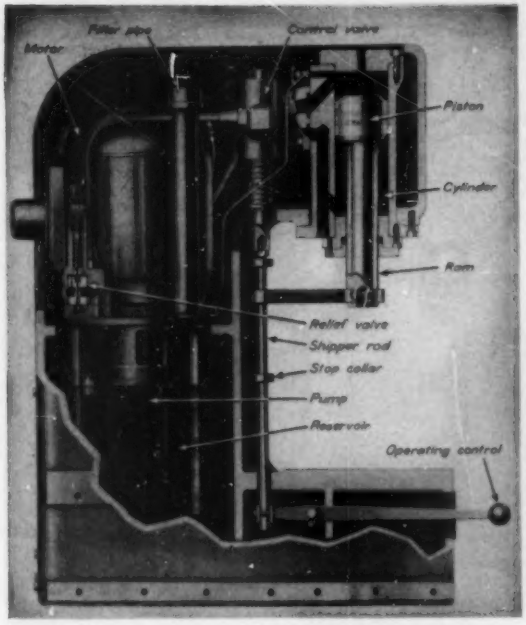
**The electrically driven Harmonic Stock Feed attachment makes possible production of as many as 50,000 parts per hr on the Denison Multipress. Wide, stepless variations in speed and feed characteristics are provided within limits of the equipment. The accessory automatically feeds strip stock to punching dies and synchronizes action of the press ram through harmonic motion. Feature of the design is that the electrically driven feeding mechanism enslaves the hydraulic press ram and controls its working movements. The drive of the Harmonic Stock Feed actuates the ram control valve and also the arm that grips, advances and releases the strip stock. The Denison Engineering Company is in Columbus 16, Ohio.**



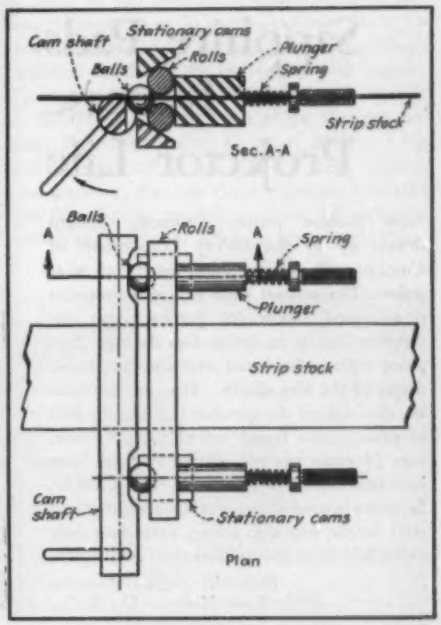
FEED UNIT MAY BE MOUNTED on either side of the press to facilitate its use for pushing or pulling the strip material. The mounting chosen depends on the specific job requirements. The unit is designed so that it can be positioned on its side if necessary. Thus, it is adaptable for use with a press ram that operates horizontally. Feed accuracy of plus or minus .002 in. is obtainable. The distance travelled for each feed cycle is regulated simply by changing the throw of a crank. All adjustments are simple and easy to make.



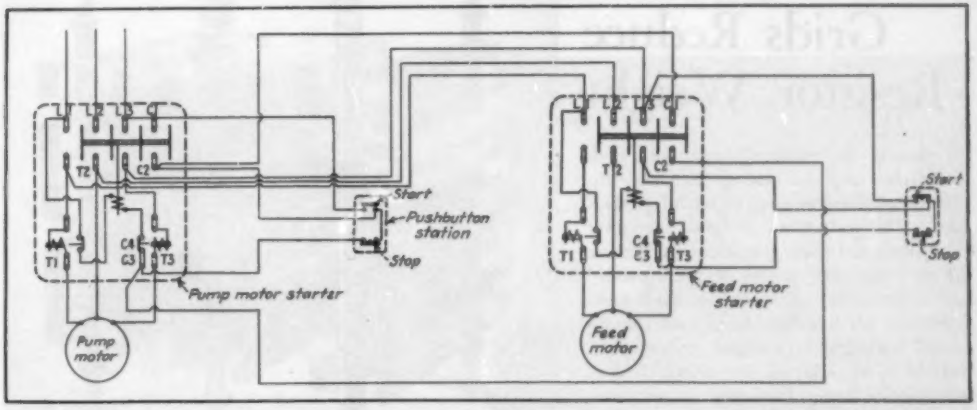

SEQUENCE OF OPERATION is revealed in this schematic of the feed mechanism. The motor-driven valve control crank actuates the spool of the ram control valve through a series of linkages. The spool directs oil alternately to the top and bottom of the cylinder. At the same time, the lower crank causes the stock gripper arm to oscillate. When this arm oscillates in one direction, gripper jaws are loosened by action of the threaded gripper assembly. When the arm reverses its motion, the jaws tighten. With the forward motion of the gripper assembly, material is advanced a predetermined distance, equal to the throw of the lower crank. Thus, the feed movement is mechanically synchronized with the up and down movements of the press ram.




CHOICE OF HYDRAULIC ACTUATION makes press operation very flexible. Speed of ram descent in the Model MCO2 can be varied between 20 and 200 in. per min. The length of stroke is set by adjusting movable stopcollars on the ram control shipper rod. Maximum pressure can be exerted regardless of the stroke length. For high speed operation, short ram strokes are selected. A full line of controls and accessories are available for the press.




HOLDING MECHANISM allows material to be fed in one direction only. In each cycle, the spring pushes the plunger and forces the rolls against the stationary cams. These in turn force the rolls against the strip stock, gripping it firmly. The stock is released as the rotating cam shaft pushes balls against rolls away from the stationary cams, allowing them to spread.

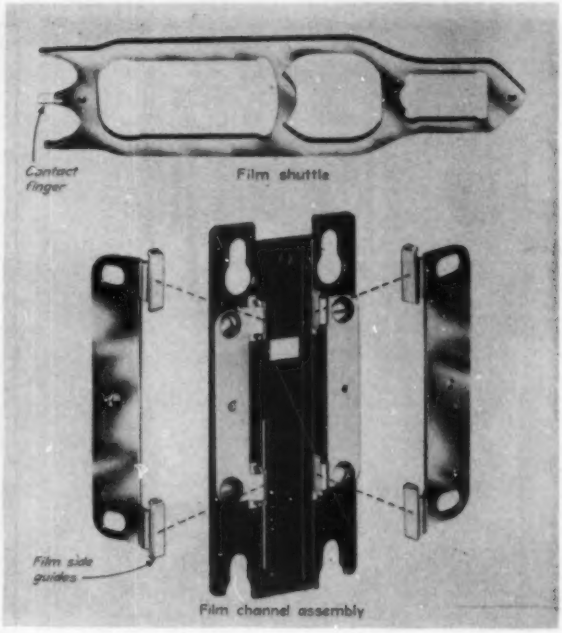



MAGNETIC CONTROLLERS and push-button stations are provided for both press feed motors. These are interlocked to prevent damage should the buttons be operated in an incorrect sequence. The feed cannot start unless the press pump is running. Also, the pump motor cannot be shut off unless the feed motor is stopped first. Should overload develop on the pump motor, it cuts out automatically. Simultaneously, the power supply to the feed motor will be cut off. If the feed is operating and the pump is not, the mechanism is protected by a shear pin in the linkage. Feed speed is regulated by changing the V-belt position on the 5 sheaves of the cone pulley assembly or by adjusting the pulley on the motor shaft. Ram piston is double-acting for positive withdrawal.

# Sapphire Pads Increase Projector Life

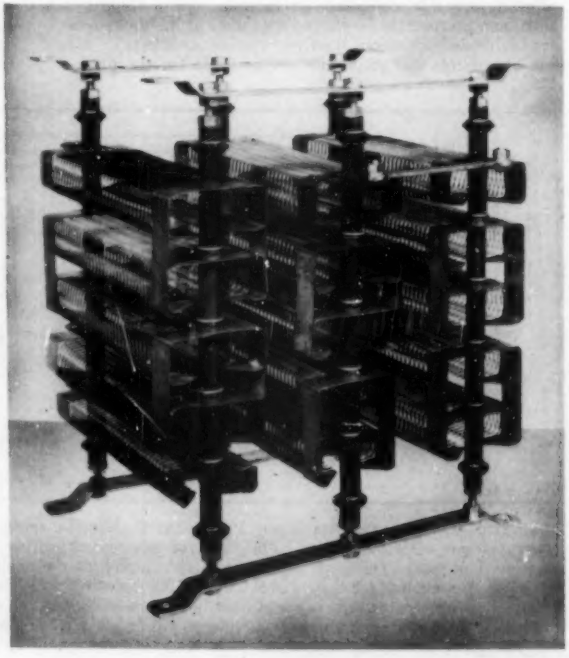
New motion picture projector designs drawn up by the DeVry Corporation of Chicago call for sapphire inserts at wear points. The normal wear life of a projector is increased almost 400 percent. Also, the sapphire inserts minimize film damage. Sapphire replaces hardened steel for the contact finger of the film shuttle. The cam activated shuttle engages the sprocket holes in the film to place a new frame before the projection lens 24 times per sec. Finger life has been increased from 250 hr to more than 1,200 hr. Sapphire is used in place of chromium plated steel for the film side guides, extending their useful life from 500 to more than 2000 hours.

*Industrial Products Division of the Elgin National Watch Co.*



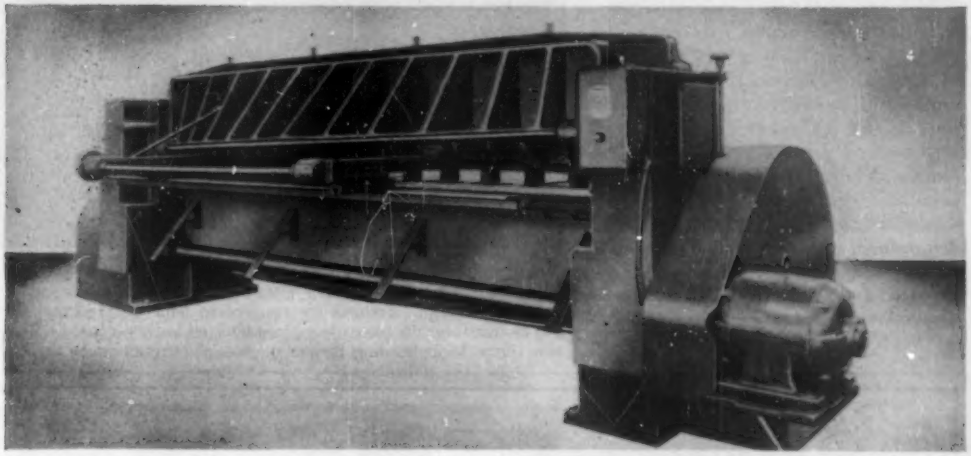

# Expanded Metal Grids Reduce Resistor Weight

In place of the wires, ribbons or cast grids ordinarily used as heating elements, the "Multipath" resistor employs mesh-type sheet metal. This resistor was designed for power dissipation and heating applications. Because of the large surface area of the expanded metal sheets, they dissipate heat much more effectively on a weight basis than conventional resistors. In addition, the mesh is formed so as to be self-supporting. It does not require heavy insulators or refractory material for support. The maker, Exmet Electrical Corporation of 59 Park Ave., New York City, uses stainless steel or aluminum-containing alloys for the construction of these resistors. They are practically non-inductive at power line frequencies.

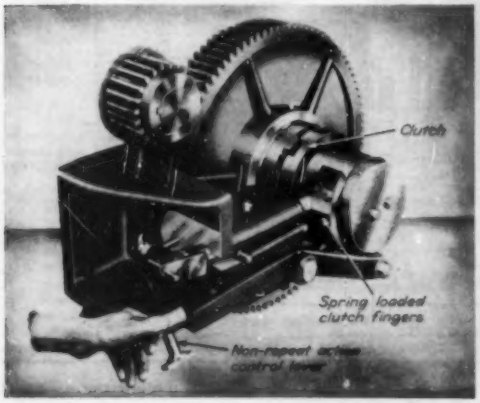


# Drive Arrangement Adds Stability To Large Power Shearing Machine

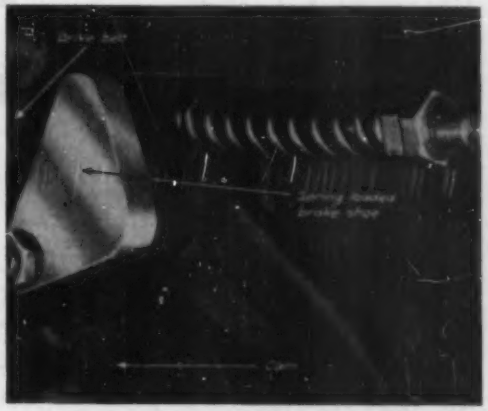
**The 122 in. knife of this electrically driven shearing machine operates at speeds up to 60 strokes per min. A 7½ hp motor and 700 lb flywheel drive the knife assembly through a manually actuated clutch. At the instant of clutch engagement, there is a heavy unbalance of forces that tends to shift the machine. Because of this, engineers of the Wysong and Miles Company of Greensboro, N. C., made stability a big factor in their design. They use massive steel castings throughout the machine. Also, the drive apparatus is located as close to the floor line as possible to lower the center of gravity. Clutch is adjustable for repeat or non-repeat action.**



THIS POWER SHEAR CUTS 10 GAGE STEEL SHEETS up to 10 ft in width. Bed, end frame, knife bar and top girders are one-piece, semi-steel castings. Sections are ribbed to provide strength and weight where needed. Motor, clutch and drive gears are mounted close to the floor line. This tends to stabilize the 8 ton machine.



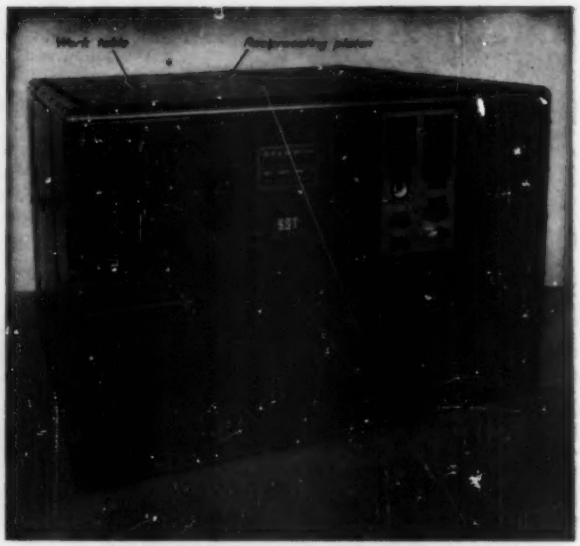

SHEARING ACTION IS INITIATED by engagement of 9-jaw clutch. The clutch can be set for continuous or non-repeat shearing by means of the control lever shown. Clutch is of forged alloy steel.



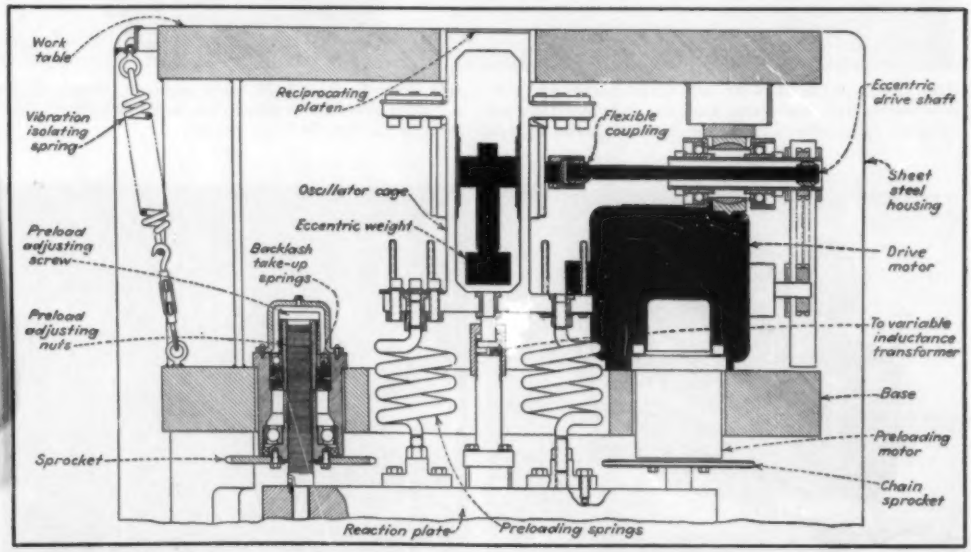
CAM CAUSES SPRING-LOADED BRAKE TO ENGAGE only at the top of the stroke. This positive release mechanism eliminates drag on the down stroke, diminishes wear and reduces possibility of over-heating or bindi.g.

# Inductance Unit Regulates Fatigue Loads

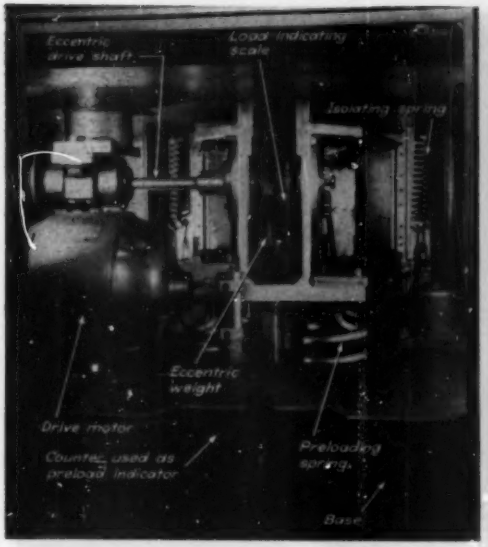
**Vibrating loads as high as 10,000 lb can be obtained on the Sonntag Model SF-10-U Machine. Using this machine, fatigue tests can be performed on many of the larger machine parts and assemblies. Outstanding feature of the new device is the means for compensating for load variations caused by permanent deformation of the specimen during test. An electrical circuit detects deformation, causing operation of a load-setting motor. The Sonntag Scientific Corporation, a division of the Baldwin Locomotive Works, makes the fatigue tester.**



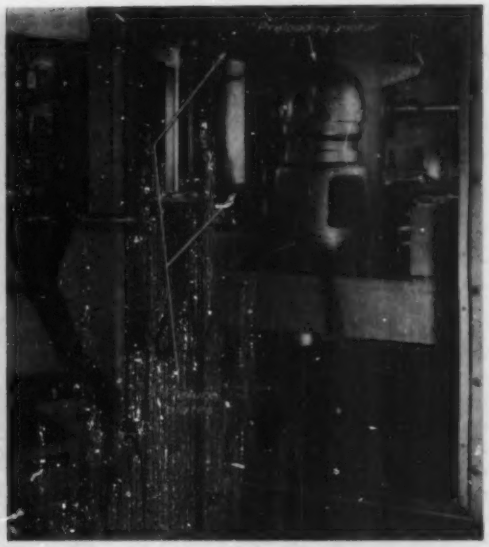

WORK TABLE OF FATIGUE TESTER is an accurately ground plate of solid steel. Tapped holes and T-slots facilitate the use of fixtures of almost any design. Fixtures are required to hold the specimen and also to transform the platen vibrations into the loading desired. Tension, compression, bending, torsion, or combined stresses can be applied.



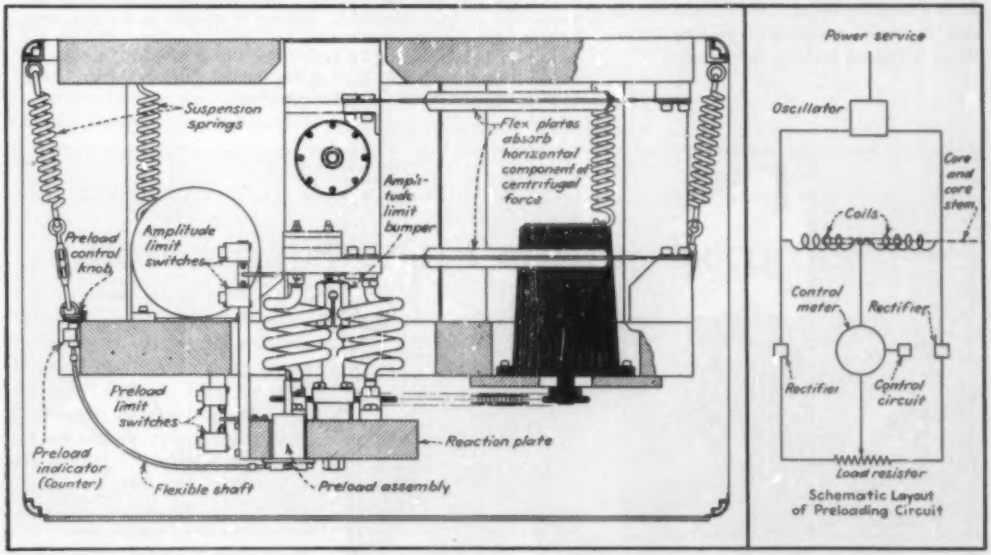

ROTATION OF ECCENTRIC WEIGHT SETS UP VIBRATIONS in the oscillator cage, which transmits them to the platen. These vibrations constitute a sine wave type of load, whose peak value can be varied up to 3,000 lb. By means of the preloading springs, a unidirectional force can be superimposed on the vibrating force. Using these combined forces, the maximum force obtainable in one direction is 10,000 lb. The initial tension or compression in the preloading springs is determined by the relative position of the base and reaction plates. The separation of these plates can be varied by the motor-driven preload adjusting nut. This nut is in two sections, which are keyed together.




MAGNITUDE OF THE VIBRATING FORCE depends on the setting of the eccentric weight. The amount of eccentricity is measured by a micrometer-like arrangement of scales. Each division of the circumferential scale, which is marked on the surface of the weight, represents 10 lb. of force.



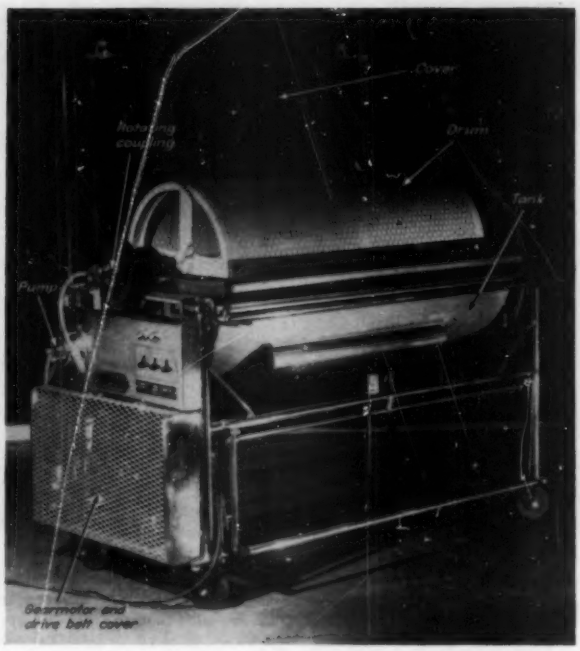

ENTIRE LOADING MECHANISM is suspended on coil springs. These isolate vibrations from the housing and frame. Four flexure plates absorb the horizontal components of the force set up by the eccentric weight without interfering with vertical motion. Thus, the load is a purely vertical force.



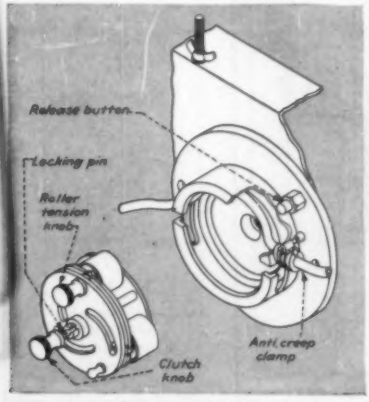

IRON CORE OF A VARIABLE INDUCTANCE UNIT is connected to the oscillating cage. The coils are mounted on the reaction plate and make up two arms of an inductance bridge. When deformation of the specimen causes a change in the mean position of the cage, and hence in the spring preload, an unbalance is produced in the bridge circuit. The resulting flow of current through the control meter actuates the control circuit of the preload motor. This motor rotates the preload adjusting nuts so as to reposition the reaction plate with respect to the cage. Motor operations continues until the coils are again symmetrically located around the core.

# Allis-Chalmers Builds Mechanical Kidney

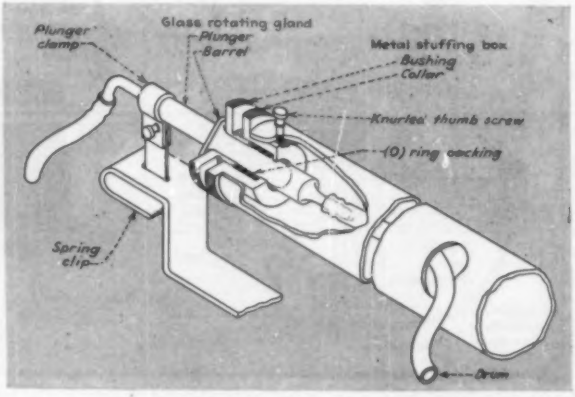
**This machine is a mechanical counterpart of the human kidney. Basically, it comprises a rotating drum upon which is wound a length of plastic tubing. Drum and tubing are partially submerged in a liquid bath. Blood pumped through the machine is purified by the passage of poison molecules through the walls of the tubing. Engineers of the Allis-Chalmers Mfg. Co. in Milwaukee based the kidney on work done by Dr. W. J. Kolff of Holland. Chief design features are a simple non-metallic rotating coupling, the use of plastic coated aluminum and a roller-actuated pump. The rotating coupling is a modified hypodermic syringe. By adapting the syringe, the designers were able to avoid complicated packing problems. Original packing was enough.**




DRUM AND TANK OF FIRST KIDNEY are constructed of aluminum and coated with a vinyl compound. Balance of machine is stainless steel. In operation, a ¼ hp motor rotates the drum at 18 rpm through the rinsing fluid contained in the tank. The 140 ft of plastic tubing are wound about the drum to form an Archimedean spiral. Action of the spiral pumps the blood through the tubing.



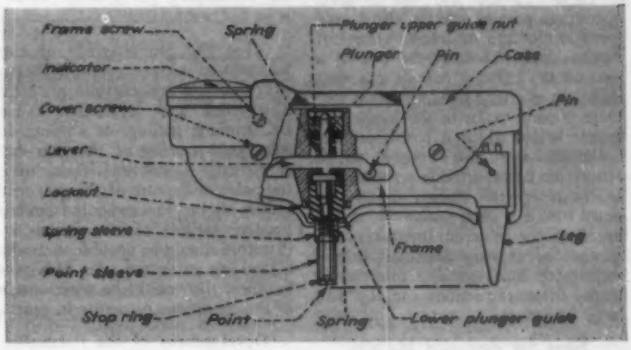

BECK PUMP RETURNS BLOOD TO PATIENT through bubble collector and clot filter. A belt from the drum drive motor rotates the cage upon which 3 rollers are mounted. These rollers exert a milking action on the tubing and push the blood along ahead of them. The blood always remains below rinse surface.




ROTATING OR SLIP-RING COUPLINGS connects the drum tubing to the stationary lines leading to and from the patient. The design of these couplings is actually a clever adaptation of a hypodermic syringe. To form the rotating joint, the ends of the hollow plunger in a syringe were cut off. The resulting tube becomes the stationary member of the joint. The body of the syringe rotates with the drum and is connected with the plastic tubing.

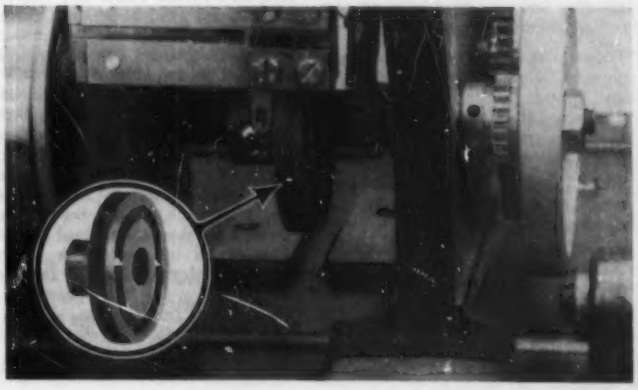
# Portable Hardness Testing Device

The Barber-Colman Impressor enables inspection personnel to make rapid, on-the-spot hardness tests on finished assemblies or raw stock. Weighing 12 oz, the instrument is designed for one hand operation. The tester detects hardness by measuring the depth of penetration of a spring loaded indenter into the specimen. The accurately ground indenter point is protected by a sleeve, which is also spring actuated. When the instrument is pressed against a specimen, the sleeve slides back to allow the indenter point to penetrate the non-ferrous or plastic material. A series of linkages translates the distance of penetration into rotation of a dial pointer. The dial is located at the top of the instrument where it is always visible to the operator. Dial graduations read from 1 to 100. By use of calibration charts, readings on the indenter point to penetrate the to Rockwell, Brinnell and other common scales. The maximum dial reading corresponds to a Rockwell E rating of 107. All adjustments are enclosed in the case. The Barber Colman Company is in Rockford, Illinois.




# Powdered Metal Cam for Recorder

This cam actuates the backspacing mechanism of the Dictaphone Time-Master recorder. At first, the designers tried cast iron. The "figure 8" groove was machined into the casting and two rise points inserted into the groove. This proved to be impractical cost-wise. An attempt to make the cam from brass by the lost wax process gave an unsatisfactory bottom to the groove. Powder metallurgy proved an ideal solution. The irregular surface of the cam face lent itself to the powdered metal process. The Wel-Met Company of Cleveland makes the cam.



# Determining Gear Tooth Surface Durability

A proposed method of gear design, based on the relationship between gear life and the surface condition of the teeth, that has proved accurate for a large number of spur and helical gears. Formulas, charts, and their application to specific problems.

DAVIS M. WOOD, M.E.

ALTHOUGH A NUMBER OF METHODS have been developed for the design of general purpose gears, most, if not all, of these (1) are restricted to gears operating within specific load and speed ranges and in definite classes of service; and (2) treat the life of a gear on an "either it does or it doesn't basis", thus giving the impression that there is some point in the loading of a gear below which it has a virtually unlimited life and beyond which failure can be expected in a short time. If, however, the design method is based on the compressive stress induced in the material and takes cognizance of existing formulas to prevent tooth breakage due to dynamic loads, these restrictions can, by and large, be ignored.

### Basis for Proposed Method

Actually, there are four modes of gear failure that are generally recognized:

LUBRICATION FAILURE. This is caused by the breakdown of the oil film between the mating gear faces, thus allowing intimate metal to metal contact and eventually causing failure.

TOOTH BREAKAGE. This is a purely physical failure that results when the load applied to a tooth causes stresses that exceed either the ultimate strength of the material or the endurance limit of the material in the bending of the tooth.

FAILURE OF THE GEAR SURFACE DUE TO "COMPRESSIVE FATIGUE". This type of gear failure occurs when the unit compressive stresses in the material beneath the contact surfaces of the gear exceed the "endurance limit" of the material. It happens only after considerable operational time has been obtained from the gear.

ABRASION. This mode of gear failure could not by any analysis be blamed upon the gearing since it is caused by foreign material becoming entrained in the lubricating oil and actually grinding or lapping the gearing while it is in operation.

Given the proper grade of clean lubricant in adequate supply, abrasive wear due to gritty contaminants can be disregarded and lubrication failure, i.e., scuffing, galling, or welding and subsequent tearing of the gear faces is virtually unknown. Thus, up to the point of rupture of the gear teeth, failure can be produced only from compressive fatigue of the material. It therefore should be possible to produce a load-life curve for steel of a given hardness that would be representative of the conditions occurring in gearing.

### Development of the Formulas

Service information on a wide variety of gear sizes and loadings was plotted in an attempt to correlate the relationship between the life of a gear in number of tooth contacts or revolutions and the compressive stresses as computed by the Hertz and Stribeck formulas for solid bodies with curved surfaces in contact under compression. The results obtained were so erratic as to make their use impossible.

A study of the gear failures showed that gears operating at low peripheral velocities could withstand a considerably higher stress for a given length of life than gears operating at higher velocities. Accordingly, an examination was made of the Buckingham equation for the dynamic load on gear teeth caused by inaccuracies in the gear and tooth profile. In this formula,

$$W_d = \frac{0.05V\,(FC + W)}{0.05V + \sqrt{FC + W}} + W$$

$V$ is the velocity at the pitch line in fpm, $F$ is the face width, and $W_d$ represents the equivalent load placed on the gear by the combined action of the static load $W$ and the dynamic effect of the errors in cutting together with the elastic deflection of the material, represented by the constant $C$.

The effect of any sudden application or release of a load varies as the square of the speed of application or release, so that errors caused by eccentricity and runout, although of relatively large magnitude, are applied so slowly as compared to the spacing and involute errors that their effects appeared neglible. Therefore, a series of representative new gears were carefully checked for their tooth-to-tooth errors and the constant $C$ in the Buckingham equations was re-evaluated for the mean value found. Again the equivalent dynamic load was computed, using the new value of $C$ and plotted against the service life. A great improvement in the regularity of the variation of life with respect to compressive stress was found. However, considerable variation was present and the results were still not satisfactory.

Since the evaluation of the constant $C$ in the Buckingham formula is of the greatest importance in determining the true effect of manufacturing errors on the actual load applied to the gear tooth, and since the formula did not check with service data when these errors were measured on sample gears, it was felt that the Buckingham formula should be re-written to obtain the dynamic load in lbs per in. of tooth face, as follows:

$$W_d = \frac{0.05V\,(C + W)}{0.05V\,\sqrt{C + W}} + W$$

where both $W_d$ and $W$ are in lbs per in. of face.

When this value for load was used to compute the compressive stresses, which then were plotted against gear

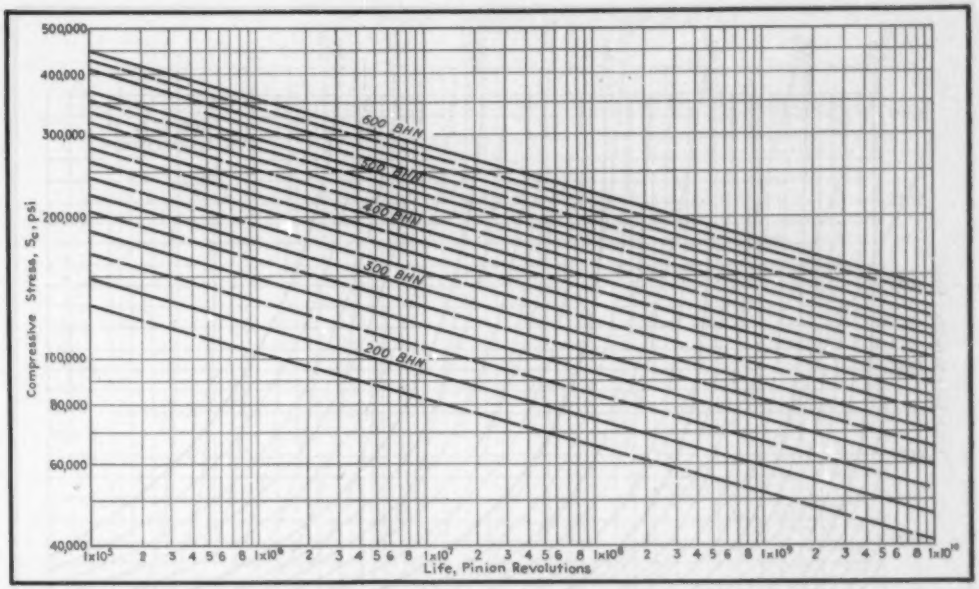



**Fig. 1—Relationship between the compressive stress and hardness on gear life for steel gears. The chart can be used to solve for the life expectancy of spur, helical, and bevel gears, but if applied to crowned gears, inaccurate results are obtained.**

life as shown in Fig. 1, consistent results were obtained on several hundred gears ranging in hardness from 250 to 600 BHN.

In developing a criterion for surface durability, the beam strength of gear teeth has been investigated only sufficiently to be able to predict that surface fatigue failure due to the compressive stresses would occur before the gearing would fail due to a bending failure at the root of the teeth. When using the Lewis formula for the beam stregnth of gear teeth

$$W = \frac{SFY}{P}, \text{ where}$$

$S$ is the allowable unit stress in psi, $P$ is the diametral pitch of the gear, $F$ is the face width of the gear in in., and $Y$ is a constant depending on tooth form, the $Y$ factor may be taken as the tabular value, widely published, when standard tooth profiles are used. If any modification of the tooth profile is required for manufacture or structural reasons, it will be necessary to graphically determine the value of $Y$ from a scale layout, preferably five or ten times full size, which has been generated as outlined by the Gleason Works, A. O. Almen of General Motors Corporation, and by other investigators and concerns.

However, it is felt that to make a satisfactory analysis by the Lewis formula, it is necessary to use the value of the dynamic load, $W_d$ as computed from the modified Buckingham equation. A bending stress based upon $W_d$ that does not exceed 25 to 30 percent of the ultimate stress has been found to produce surface fatigue failure before tooth root failure in the great majority of cases studied.

## Determining the Error in Action

As previously mentioned, determination of the tooth-to-tooth error in action of a gear pair is of major importance with this method of predicting life. This error in action must be that departure from true rolling motion occasioned as the gear pair rolls through one circular pitch.

Since this error is considerably smaller than the commonly accepted idea of gear error, its accurate measurement becomes somewhat difficult. Three methods can be used to obtain consistent results. These are in the inverse order of their preference:

(1) By measuring the actual tooth-to-tooth error with a vernier caliper. By taking a fairly large number of measurements per gear, it is possible to attain a fairly complete picture of the variations in tooth spacing and tooth thickness, which are ordinarily the major causes of gear error.

(2) By rolling a pair of gears together on a gear testing machine such as the Brown and Sharpe machine and noting the change in center distance as the gears are rolled from one tooth to another.

(3) By checking the gear error on one of the specialized universal gear checking machines that are capable of individually charting or measuring the whole field of gear errors: profile errors, lead errors, pressure angle errors, and runout.

In the absence of any more elaborate means of checking gearing than the common vernier caliper, which at best cannot be read more closely than 0.0005 in. the following assumptions of gear error may be made: For the average commercial quality generated gear in which no particular care is taken in cutting, or for gears that are carefully cut and of good quality but are heat-treated following their cutting, an error value of 0.001 in. may be safely used, and a corresponding value of $C$ in the Buckingham equation may be selected. For good quality generated gearing that is cut following heat treatment or for extremely high quality gearing that is heat treated after cutting—with special care being taken to minimize distortion—an error value of 0.0005 in. may be assumed. For gearing that is carefully finished following heat-treatment, either by extremely careful finish cuts in the generating process with ground form hobs or by shaving, or in the case of hard gears, by lapping or grinding, an error value of 0.00025 in. is not unreason-

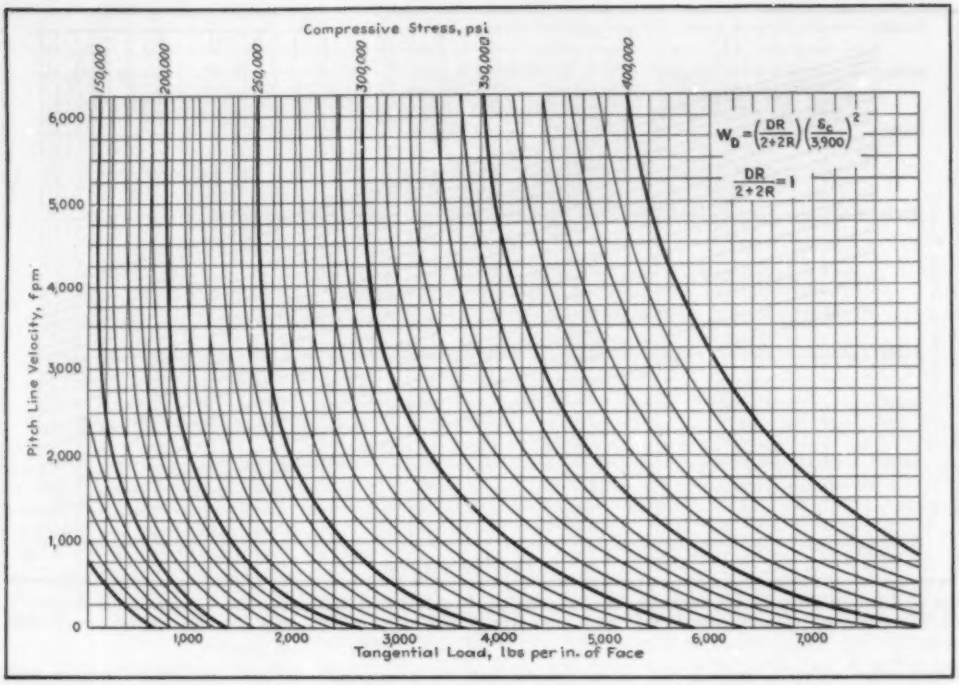



**Fig. 2—Relationship between the nominal compressive load, the dynamic load, and the pitch line velocity for 20 deg pressure angle steel spur gears. The value for $C$ of 1660 which was used for this curve corresponds to an error in action of 0.001 in.**

able. It must be realized that values such as these can only represent average good practice, and especially in the case of gearing of other than commercial quality, it is essential that actual error determinations be made either on sample gearing or on similar gearing produced by the same process.

### Application of the Method

As with the use of all gear design methods, and for that matter the selection of bearings, this design method is limited to the functions that may be directly determined.

It may be used to determine:

(1) The life of a gear pair of known dimensions and hardness operating under known conditions of loading.

(2) The minimum hardness requirements for a gear pair of known dimensions and loading for a given life..

(3) The minimum face width of a gear pair of known diameters, hardness and loading conditions, for a given life.

(4) The allowable loading conditions of a known gear pair for a desired life.

Functions (1), (2), and (3) are those that are commonly required, since in nearly all applications the geometrical considerations will limit the physical size of the pair, and mechanical requirements will fix the loading conditions. In handling the solution for one of these three basic unknowns, the following procedure is recommended:

(1) Reduce the required loading conditions to lbs force per in. of face applied tangentially at the pitch radius, and the speed to a peripheral velocity in fpm at the pitch radius.

(2) Using the modified Buckingham dynamic loading equation and an appropriate value for $C$ dependent upon the method of manufacture and the class of gearing required, compute the dynamic load applied to the gear.

(3) Compute the double radius of curvature of the gea rtooth at the pitch line for both members of the gear pair, using the follcwing equation:

$$d = 2R \sin \theta$$

where $R$ is the pitch radius of the gear and $\theta$ is the pressure angle in deg. Compute the compressive stress $S_c$ in the material, using the Hertz equation

$$S_c = 0.591 \sqrt{W_d E \frac{(d_1 + d_2)}{(d_1 d_2)}}$$

where $d_1$ is the double radius of tooth curvature of the larger gear and $d_2$ is the double radius of tooth curvature of the smaller gear.

(4) Compute the total number of contacts required for the desired life. In most cases this will be the number of revolutions of the smaller gear of the pair.

When hardness is the desired unknown, the minimum hardness may be read from Fig. 1 at the point corresponding to the life and compressive stress determined in steps (3) and (4). Should the face width be the unknown factor, an allowable compressive stress $S_c$ may be determined from Fig. 1 from the known hardness and desired life. Should this compressive stress be more than that computed in step 3, the face width used in computing $S_c$ must be increased by the square of the ratios of $S_c$. For example, if the compressive stress as computed in step 3 were 300,000 psi and that stress which would be permissible for the desired life was found from Fig. 1 to be 200,000 psi, the face width used in computing the 300,000 psi value must be multiplied by 9/4 [(3/2)²]. Similarly, the life of a gear pair may be determined from Fig. 1 using the value

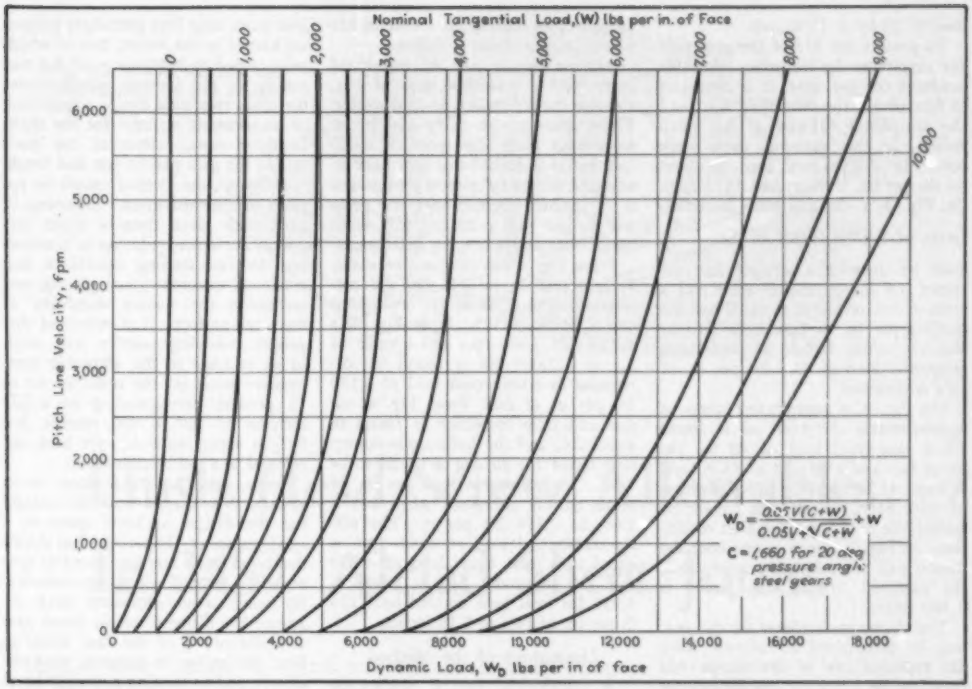



**Fig. 3—Relationship between the tangential load, the pitch line velocity, and the compressive stress for steel spur gears with a 20 deg. pressure angle. Curves are based on 4.0 in. one to one ratio gears but others can be developed for any conditions.**

of $S_c$ computed in Step 3 and the gear hardness.

In many cases, particularly when the ratio of the gear pair is relatively large, it may be advantageous to use different hardness for the two gears. In the example just given only the life of the smaller gear of the pair was considered. However, by computing the number of contacts required of the larger gear and using the same value of $S_c$ computed for the smaller gear, the minimum hardness requirement for the larger gear may be determined from Fig. 1 very easily.

To eliminate much of the time consumed in the above calculations when a number of gear pairs must be checked, a series of three supplementary charts have been developed. The relationship between the nominal gear load $W$, the velocity $V$, and the dynamic load $W_d$ is charted in Fig. 2. This chart was plotted by solving the modified Buckingham equation for spur gears using a value for $C$ of 1660 corresponding to an error in action of 0.001 in. for steel gears with a 20 deg pressure angle.

The relationship between the nominal gear load $W$, the velocity in fpm $V$, and the compressive stress $S_c$ for a standard gear pair is shown in Fig. 3. This is in reality a chart of constant dynamic load corresponding to the values of compressive stress $S_c$ that are indicated. The Hertz equation for compressive stress may be reduced to the form

$$W_d = \frac{D\,R}{2+2\,R}\left(\frac{S_c}{3900}\right)^2$$

by substituting the appropriate values for the gear material and pressure angle used—in this case, for steel gears having a 20 deg pressure angle. To eliminate the effect of gear size in Fig. 2, $\frac{2+2R}{DR}$ has been made equal to one by basing these calculations upon a pair of gears having a 4 in. pitch diameter and a 1:1 ratio. Additional charts similar to Figs. 2 and 3 may be developed for any order of error that may be required.

A nomogram at the left of Fig. 4 provides a ready solution for the value of the quantity $\frac{DR}{2+2R}$. This nomogram is suitable for the solution of this quantity for values of pinion diameter ranging from 1.0 to 15 in., and for gear ratios ranging from 1:1 to 12:1. Values of the total quantity $\frac{2+2R}{DR}$ are read from the center line by laying a straight edge from the pinion diameter, $D$, on the left hand line to the value of the ratio, $R$ on the right hand line.

The correction chart at the right of Fig. 4 was developed for helical gears by solving the modified Buckingham dynamic load equation for helical gears

$$W_d = \frac{0.05\,V\,(C\,\mathrm{Cos}^2\,a + W)\,\mathrm{Cos}\,a}{0.05\,V\,\sqrt{C\,\mathrm{Cos}^2\,a + W}} + W$$

for a number of values of helix angle and for the same conditions as were used for Fig. 2. This helical gear correction factor is the ratio between the value of dynamic load which would be obtained for spur and helical gears of the same size with helix angles between 0 and 45 deg.

### Solution of Typical Problems

As an example of how a gear set is designed, take the case of a pinion having a 3.0 in. pitch dia, 4.0 in. face, and 20 deg pressure angle, full depth spur teeth. Assume that the gear ratio is 5:1, the pinion hardness is 350 BHN, and that the set is carrying a

load of 10 hp at 1750 rpm.

To predict the life of the gear pair and determine the minimum allowable hardness for the gear, it is necessary to first obtain the tangential load and the peripheral velocity at the pitch radius. In this example, these work out to be 239 lbs total load, or about 60 lbs per in. of face; and 1376 fpm. On Fig. 4, a size and ratio correction factor of 1.22 is found on the $\frac{DR}{2+2R}$ scale by drawing a straight line between 3.0 in. on the $D$ scale and a ratio of 5:1 on the $R$ scale. When the loading per in. of face is divided by this correction factor, an equivalent tangential load of 49.2 lbs per in. of face is obtained.

On Fig. 3, a compressive stress of approximately 120,000 psi is found for a tangential load of 49 lbs per in. of face and a velocity of 1376 fpm. A stress of 120,000 psi and a hardness of 350 BHN corresponds to an expected life of 2.5 x $10^8$ pinion revolutions on Fig. 1. Since in one hour the pinion will make 105,000 revolutions, the expected life of this pinion is 2,380 hours.

The minimum hardness for the gear may be determined as follows: Since the expected life of the pinion was found to be 2.5 x $10^8$ revolutions the gear must have an expected life of one-fifth of this or 5 x $10^7$ revolutions. Since compressive stress in both gears will be the same, a hardness at 300 BHN is found on Fig. 1 at the point corresponding to a compressive stress of 120,000 psi and a life of 5 x $10^7$ revolutions.

A similar example involving a somewhat different solution to determine the gear proportions for a desired life would be carried out as follows:

Assume that a pair of carburized gears have a reduction ratio of 2:1, and that the pinion is 6 in. in diameter. These gears are to carry 300 hp at an average pitch line speed of 2,000 fpm and it is desired that they have an expected life of $10^8$ pinion revolutions. It is further assumed that the gears will be cut with a 20 deg full depth tooth form and a 20 deg helix angle.

From Fig. 1 the compressive stress, $S_c$ is found to be 212,000 psi corresponding to a life of $10^8$ revolutions and a BHN of 575. From Fig. 3, a velocity of 2,000 fpm and a value of $S_c$ of 212,000 psi is found to correspond to a tangential load of 1,130 lbs per in. of face. From Fig. 4, the size and ratio correction is found to equal 2.0, and the helix-angle correction factor for 20 deg is found to be 1.06. The allowable load per in. of tooth face is, therefore, 1130 x 2 x 1.06 = 2,274 lbs per in. The 300 hp transmitted load at 2,000 fpm is equal to a total tooth load of 4,950 lb. The minimum face is equal to 4,950 lbs total load divided by 2,274 lb per in. of face or 2.18 inches.

### Limitations of the Method

A number of special application gears ranging from specific tooth loadings as high as 10,000 lbs per in. of face at a velocity of approximately 150 fpm to high speed gearing operating at upwards of 5,000 fpm have been designed according to the method just described and in no case has there been a premature failure that could by analysis be termed a fault of the gear design. Out of approximately 800 gear pairs, only four premature failures are known to the writer, two of which were caused by heat-treatment that was not up to the drawing specifications; the other two were due to substitution of an incorrect material for the shaft. In these cases, failure of the shaft caused the gear pair to jam and break.

However, the method cannot be applied to crowned gears. Crowning of gear teeth gives them a slight secondary curvature, reducing or eliminating the end loading conditions that are found in conventional gearing, and increasing the surface durability of the tooth surface. It is estimated that proper crowning practice will result in an increase in the allowable compressive stress on the order of 10 to 15 percent, corresponding to a life increase of 300 to 400 percent, but fatigue curves have not yet been developed to a publishable state.

Some work has been done in an attempt to produce a workable method for the design of bevel gears in a similar manner. Experience has shown that bevel gears may be treated as spur or helical gears if adequately mounted. By using as an equivalent pitch diameter the diameter of the bevel gear at a distance $\frac{1}{3}$ of the face width in from the major or nominal pitch diameter, and by treating a straight bevel gear pair as a spur pair of the same face width, excellent results have been obtained. Spiral bevel gears should be treated as helical gears in the same manner.

It should be noted that the loadings obtained by this method of gear design make good gear mounting practice mandatory. The effects of gear and/or mounting deflections has been found to be negligible if the combined torsion and bending deflections result in an apparent increase in error of not more than 50 percent of the nominal gear error. In other words, for a gear having 0.001 in. tooth-to-tooth error, not more than 0.0005 in. per inch of face deflection may be tolerated.

A deflection analysis should be made for all suspect systems and the gears and their mountings re-proportioned or else life confirmation tests should be run if the deflection error is found to be too great.

While this method of gear analysis is not considered to be completed, since the total experience to date has not been sufficient to warrant any such statement, the results that have been obtained thus far have been so consistently accurate that it shows great promise of becoming an exceedingly useful and practical tool for the design of gearing, especially since it results in definite values for gear life.

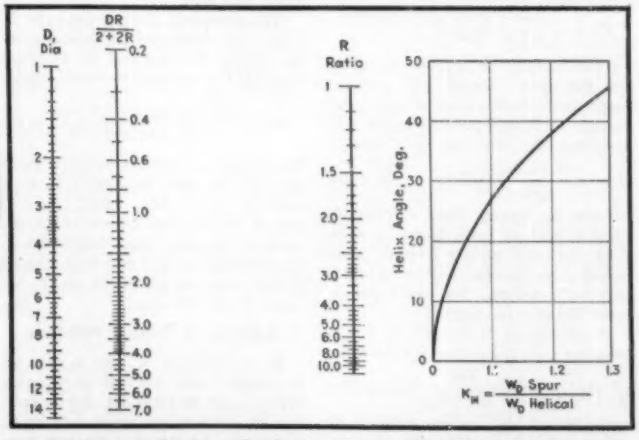



**Fig. 4—Nomogram for size and reduction ratio correction factor, left, and loading correction factor curve for helical gears, right. This latter factor is the ratio between the dynamic load on spur and helical gears of the same size and loading.**

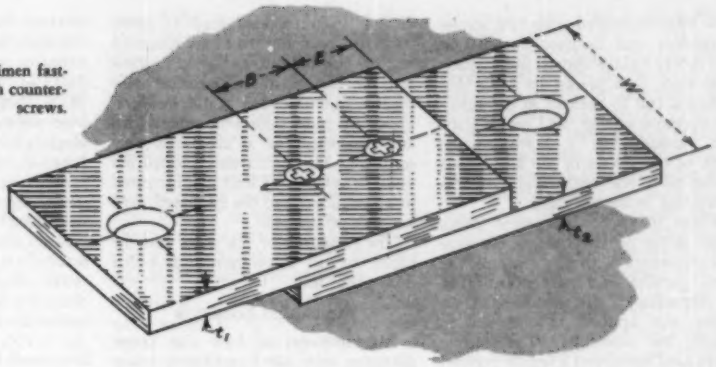



Fig. 1—Lap joint specimen fastened with 100 deg flush countersunk head machine screws.

# Flush Head Screw Allowables In 24ST Alclad Sheet Joints

Tests of shear loaded lap joints to determine a set-criterion to be applied in defining allowable shear and bearing loads for 100 deg flush head steel screws in 24ST Alclad sheet. Allowables for flush head screws are set up for different sheet thicknesses from an analysis of test results and recommendations made for their adoption.

HAROLD G. BRILMYER
Structural Research Group,
The Glenn L. Martin Company

STATIC TESTS and service life data on various airplanes indicate that a fair approximation of the bearing strength of machine countersunk screws is 70 percent of the bearing strength of protruding head screws. Recent tests, however, indicate that in some respects this approximation is too conservative.

These tests were prompted by the increasing use of flush screws and the wider range of sheet thicknesses in highly loaded structural applications. The objective was to establish design allowables and resultant joint deflections over the entire bearing range. In addition, so as to have a complete summary of the load-deflection characteristics for screws in general, tests of protruding head screws were included in the program.

From the results of these tests, a "set-criterion" was determined that can be applied in defining allowable shear and bearing loads for flush screws.

To complement the test data, a study was made of the design allowables used for flush screws on several recent airplane designs. A further study investigated the relationship existing between protruding head and flush head rivet allowables with regard to permanent set at design yield load.

On the basis of these tests and studies, it is recommended that: (1) For flush screws in sizes up to and including $\frac{1}{4}$ in. dia, an allowable set of 0.015 in. per joint be adopted as yield criterion; and (2) For screw sizes $\frac{5}{16}$ in. dia and larger, the yield criterion be based on a set equal to 4 percent of the nominal screw diameter.

TEST SPECIMENS were simple lap joints, Fig. 1, fastened either with 100 deg flush head steel screws or with protruding head screws.

Where

$E$ = edge distance, in.
$D$ = nominal diameter of screw, in.

the edge distance $E$ for the screws was maintained at

$$E = 2D \pm 1/32 \text{ in.}$$

The general dimensions of the specimens tested are

| Screw Dia, $D$, in. | Edge Distance, $E = 2D$, in. | Back Pitch, $B = 6D$, in. | Width, $W$ |
|---|---|---|---|
| 3/16 | 3/8 | 1 1/8 | 2 |
| 1/4 | 1/2 | 1 1/2 | 3 |
| 5/16 | 5/8 | 1 7/8 | 4 |
| 3/8 | 3/4 | 2 1/4 | 4 |

The specimens tested covered the following ranges of ratios of sheet thickness $t$ to screw diameter $D$:

| Type of Screw | Range of $t/D$ |
|---|---|
| Protruding Head | 0.17 to 1.00 |
| Machine Countersunk | 0.40 to 1.00 |

### Method of Assembly

Since a close-drill (Class II Fit) was used for drilling the holes in the specimens, the shank of the screws did not fill the holes. To obtain as much uniformity of assembly procedure as possible, and ultimately to be able to determine the amount of mechanical looseness as well as the permanent set present in the joints, the following assembly methods were used.

PROTRUDING HEAD STEEL SCREW TEST SPECIMENS. These test speci-

mens were assembled with two screws in tandem and fastened finger-tight with AN315 plain aircraft nuts. Specimens were then placed in a jig that applied a 100 lb preload in the direction opposite to that used under tests. This preload, Fig. 2, bottomed the shank of the screws in the holes, thus leaving all of the mechanical looseness to show up in the test data.

While the specimens were being loaded in the jig, the screw heads were held stationary with the slots of the recess parallel and perpendicular to the centerline of the specimen. Then torque was applied to the nut to tighten the assembly. The torque values used developed a tensile preload of approximately 40,000 psi; the torque values were taken from the Air Force Handbook of Instructions for Aircraft Designers.

100 DEG FLUSH HEAD STEEL SCREW TEST SPECIMENS—MACHINE COUNTERSUNK JOINT. The method of assembly for these specimens was identical to the method outlined for protruding head screw specimens with the following addition.

Since during these tests observations were to be made of the "aerodynamic flushness limitations for screws under load," a production paint process was applied to the flush head side of the specimens. The permanent set at which the paint cracked would indicate excessive tilt of the screw head.

TEST PROCEDURES. The assembled specimen was placed in a tension type testing machine, Fig. 3, with a Glenn L. Martin Company slip indicator attached. After a zero load of about 20 lb had been applied to the specimen and the slip indicator adjusted to show zero set; the specimen was successively loaded and unloaded while measurements of joint deflection under load and permanent set at zero load were recorded. These data were plotted for small increments of load that increased in magnitude up to the estimated yield strength of the joint.

The condition of the paint and the tilting of the screw head was noted during the test.

### Mechanical Looseness

Measurements of hole size, screw diameter and sheet thickness taken with micrometers prior to assembly of test specimens gave an "indicated" mechanical looseness.

Since all of the mechanical looseness, however, was retained to show up in the test load-deflection data, it was necessary to develop a method of analyzing the test data that would define the "test mechanical looseness" for each specimen.

The test mechanical looseness was determined from the load-deflection data as shown in Fig. 4. The straight-line portion of both the permanent set and the loaded deflection curves were extended to the test zero load, where they intersect. This point of intersection, on the deflection scale, defines the test mechanical looseness.

### Test Results

PROTRUDING HEAD STEEL SCREWS IN 24SMHT ALCLAD SHEET. Measurements of hole sizes and screw diameters indicated that the average mechanical looseness for the different diameter screws varied from 0.008 to 0.013 in. For a Class II fit the maximum looseness possible (maximum hole size minus minimum screw diameter) is 0.011 in. per sheet, a total of 0.022 in. and an average of 0.011 in. for this type specimen.

Average test mechanical looseness determined from the load-deflection curves varied from 0.011 in. for $\frac{3}{16}$ in. screws to 0.004 in. for $\frac{1}{4}$ in. dia screws. NOTE: Washers were not used under the screw heads, hence the fillet radius under the heads of the $\frac{3}{16}$ and $\frac{1}{4}$ in. dia screws, depending upon the hole size, tended to center the screws in the top sheet with a resultant decrease in test mechanical looseness. Application of the assembly torque seated the screw heads on the top sheet.

100 DEG FLUSH HEAD STEEL SCREWS IN MACHINE COUNTERSUNK 24-SMHT ALCLAD SHEET. Observance of Glenn L. Martin Company minimum countersinking thickness, which is equal to approximately the head height of the flush screw, excluded mechanical looseness in the top sheet. But the bottom sheet could show the maximum possible mechanical looseness of 0.011 in. for Class II Fit, or an average of 0.005 in. for the joint.

The average mechanical looseness based on measurements of the hole size and screw diameter, for each diameter tested, varied from 0.004 to 0.007 inches.

The average test mechanical looseness determined from the curves varied from 0.003 to 0.007 in. per joint.

A perceptible separation of the paint around the screw heads was observed at a permanent set of 0.010 to 0.012 in. for these specimens. The individual test curves, however, indicate that the tilt of the screw heads was not appreciable at these sets and for all practical purposes can be ignored.

For these specimens, a permanent set of 0.010 in. defines the point at which the set curve deviates from a straight line.

It should be noted that these specimens consisted of equal top and bottom sheet thicknesses, whereas, an actual "balanced" design will consist of a bottom sheet that is thinner than the countersunk top sheet. This decrease in the thickness of the bottom sheet may cause a screw head tilt slightly greater than that observed in these tests.

A series of specimens containing $\frac{1}{4}$ in. dia screws, assembled using a high torque, were tested to investigate what effect an increase in tensile preload would have on the load-deflection

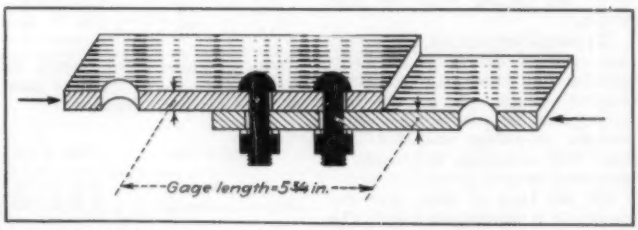



Fig. 2—Method of assembling protruding head steel screw test specimens.

**Table I—Permanent Set Present for Rivet Joints After Being Subjected to Yield Load**

| Rivet Diameter, in. | Protruding Head Rivet Joint | Flush Head Rivet Joint | |
|---|---|---|---|
| | Set Present At 2/3 Test Ult. Load, in. | Old 0.04$D$ Method, in. | Proposed Criterion 0.005 in. and 0.025 $D$, in. |
| 1/8 | 0.0005 to 0.0025 | 0.0050 | 0.005 |
| 5/32 | 0.0005 to 0.0025 | 0.0062 | 0.005 |
| 3/16 | 0.0005 to 0.0025 | 0.0075 | 0.005 |
| 1/4 | 0.005 to 0.0025 | 0.0100 | 0.0062 |

characteristics of the joint. A study of the data revealed that any change was negligible.

### Discussion of Rivet Yield Criterion

PROTRUDING HEAD RIVETS. The bearing yield strength values appearing in ANC-5 for Alclad 24ST material were obtained from bearing stress versus hole elongation curves using an offset, from the initial straight line portion of the curves, of 2 percent of the pin diameter $D$ (for one sheet). The test assembly consisted of a pin loaded in double shear, with the single sheet of the double shear joint as the test specimen.

Considering a simple lap joint made up of equal sheet thicknesses, one would expect that a set equal to 0.04 $D$ (0.02 $D$ for each sheet) would be present at calculated bearing yield load. However, a study, Table I, of protruding head rivet tests in 24ST Alclad sheet indicated, for rivets $\frac{1}{4}$ in. dia and less, that the amount of permanent set present in a simple lap joint at $\frac{2}{3}$ the test ultimate strength varies from 0.0005 to 0.0025 in., an average of 0.0015 in. per joint.

One reason why protruding head rivets do not show a set of 0.04$D$ at calculated yield load probably is attributable to the fact that the ANC-5 bearing yield is based on the bearing strength at a $t/D$ ratio of about 0.182, or a $D/t$ ratio of about 5.5. Further, no attempt has been made to take advantage of the higher bearing yield strength that is obtained as the ratio of sheet thickness to pin diameter $t/D$ approaches one. The set present in a riveted joint using this calculated yield load, therefore, would only approach the 0.04 $D$ value at a $t/D$ less than 0.182, while for the $t/D$ ratios normally used the set would be appreciably less than 0.04 $D$. This same reasoning also applies to the results of the protruding head screw tests.

A rather obvious factor that will cause a riveted joint to show a set less than 0.04 $D$ is the use of rivets in sheet combinations where $\frac{2}{3}$ the shear strength of the rivet is less than the calculated bearing yield strength.

FLUSH HEAD RIVETS. For years the set criterion for flush head rivets was based on a set equal to 4 percent of the rivet diameter. Recently, upon the insistence of several aircraft manufacturers the AP-12 Sub-Committee changed the yield criterion to a fixed set of 0.005 in., independent of rivet diameter. At the present time, since the 0.005 in. set criterion appeared to be too restrictive for large diameter rivets, the allowable set of 0.005 in. is in the process of the following further modification.

| Set Criterion | Rivet Size |
|---|---|
| 0.005 in. | Up to and including 3/16 in. dia |
| 2.5 percent of $D$ | 1/4 in. dia and larger |

In any event, it is apparent from Table I that the yield criterion for flush head rivets gives an allowable set that is equal to or greater than twice the amount present for protruding head rivets after being subjected to yield load.

It should be pointed out that the set criterion of 0.005 in. for flush rivets has been purely an arbitrary value chosen in preference to 0.04 $D$ because of its intended conservatism. For machine countersunk rivets, however, in sheet thicknesses larger than the minimum countersinking thickness, that is where $t$ is larger than 0.4$D$, the following condition exists: One and a half times the load at 0.005 in. set is greater than the test ultimate load.

This same condition is true for double dimpled rivets for $t/D$ ratios greater than 0.2, which indicates that flush rivets are critical in yield for only very small values of a $t/D$ ratio.

### Screw Set Criterion

PROTRUDING HEAD SCREW. To be able to determine the amount of permanent set present for each specimen; yield load was calculated on the basis of the following relationship:

Where

$L_{cy}$ = calculated yield load, lb
$S_{by}$ = bearing yield stress where $E$ equals $2D$, psi
$t_a$ = actual thickness of sheet, in.
$D_n$ = nominal screw dia, in.

$$L_{cy} = S_{by}\, t_a\, D_n \qquad (1)$$

The yield load $L_{cy}$ as calculated in this manner, was compared with $\frac{2}{3}$ of the allowable single shear strength of the screw used to assemble the joint. The lower of the two loads was used for the determination of the total permanent joint deflection.

The total permanent joint deflection at the set load consists of mechanical looseness and permanent set. For each

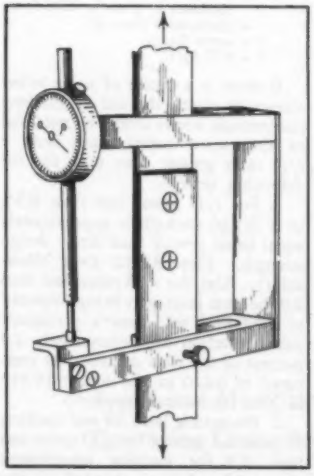


Fig. 3—Test specimen with Glenn L. Martin Company slip indicator attached.

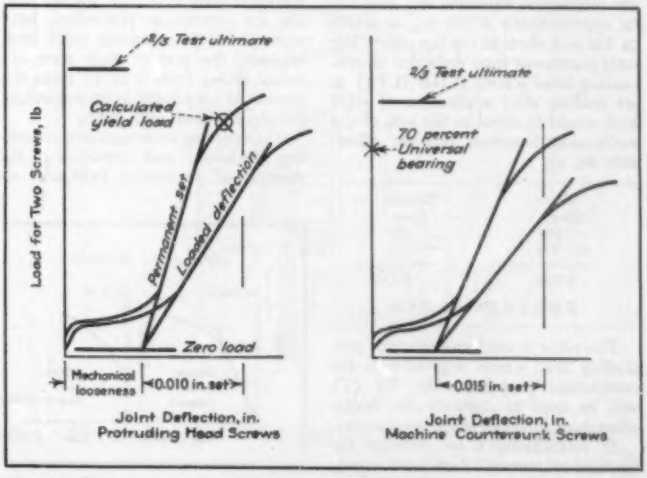



Fig. 4—Notations made on individual load-deflection curves and analysis to define test mechanical looseness. Intersection of straight lines defines mechanical looseness.

**Table II—Comparison of Machine Countersunk Screw, Rivet and 70 Percent Bearing Allowables**

| Dia, in. | Fastening | Allowable Bearing, lb per fastener | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sheet Thickness, in. | | | | | | | | |
| | | 0.072 | 0.081 | 0.091 | 0.102 | 0.125 | 0.156 | 0.188 | 0.250 | 0.375 |
| 3/16 | Mch Csk Screw | 710* | 845 | 1,000 | 1,170 | 1,520 | 1,980 | 2,125 | 2,125 | 2,125 |
| | Rivet (AP-12) | 942 | 992 | 1,035 | 1,073 | 1,131 | 1,180 | 1,180 | 1,180 | 1,180 |
| | 70 percent Bearing | 855 | 965 | 1,085 | 1,210 | 1,485 | 1,650 | | | |
| 1/4 | Mch Csk Screw | | | | 1,365* | 1,825 | 2,450 | 3,100 | 3,680 | 3,680 |
| | Rivet (AP-12) | | | | 1,690 | 1,877 | 2,000 | 2,084 | 2,084 | 2,084 |
| | 70 percent Bearing | | | | 1,635 | 2,000 | 2,500 | 2,970 | | |
| 5/16 | Mch Csk Screw | | | | | 1,900* | 2,570 | 3,270 | 4,630 | 5,750 |
| | Rivet (AP-12) | | | | | | | | | |
| | 70 percent Bearing | | | | | 2,520 | 3,130 | 3,780 | 4,700 | |
| 3/8 | Mch Csk Screw | | | | | | 2,880* | 3,720 | 5,350 | 8,280 |
| | Rivet (AP-12) | | | | | | | | | |
| | 70 percent Bearing | | | | | | 3,750 | 4,520 | 6,000 | |

* Allowables for one gage below Glenn L. Martin Company's minimum countersinking thickness.

test specimen, therefore, the permanent set present in the joint resulting from application of calculated yield load was determined by subtracting known mechanical looseness from total permanent joint deflection at set load.

Taking an average for the amount of permanent set present in all protruding head screw specimens after being subjected to calculated yield load, a value of 0.0106 in. is obtained. Using an allowable permanent set of 0.010 in. and $\frac{3}{4}$ the test ultimate load, the following relationship existed: Yield load at set of 0.010 in. equaled or was less than $\frac{3}{4}$ of test ultimate load.

Based on these test data, the average test mechanical looseness was found to be approximately 0.008 in., or 0.004 in. for each sheet in the lap joint. The total permanent joint deflection of protruding head screws (Class II Fit) at set reading after application of yield load would be equal to the sum of the mechanical looseness and the allowable set, or

| Top Sheet | Bottom Sheet |
|---|---|
| 0.004 | 0.004 |
| +0.005 | +0.005 |
| 0.009 | 0.009 |

$0.009 + 0.009 = 0.018$ in.

The value of set determined for protruding head screws is given here for comparison purposes only. Eq (1) will be used to compute the design allowables for protruding head screws.

In establishing a set criterion for machine countersunk flush head screws, it is reasonable to apply what has been learned concerning the behavior of protruding and flush head rivets relative to their yield criterion. Therefore, it is recommended that a set of 0.015 in. per joint be adopted as yield criterion for screw sizes up to and including $\frac{5}{16}$ in. dia, and that an allowable set be based on 4 percent of the nominal screw diameter for $\frac{3}{8}$ in. screws and larger. This value appears to be reasonable and necessary for the following reasons.

1. Design allowables based on this criterion are in close agreement with allowables used previous to these tests, Table II, which have proved satisfactory in the static and service life tests.

2. The recommended set for flush screws is only 0.005 in. greater than the set present in protruding head screw joints at calculated yield load, whereas, the present flush rivet criterion allows from 2 to 10 times the amount of set present in corresponding protruding head rivet joints.

3. Observing minimum countersinking thickness, and considering the amount of permanent deflection allowed past the linear portion of the set curve, the load-permanent deflection curves, Fig. 5, for machine counter sunk screws at 0.015 in. set compare favorably with the same type data for machine countersunk rivets in that both criteria allow 0.005 in. set.

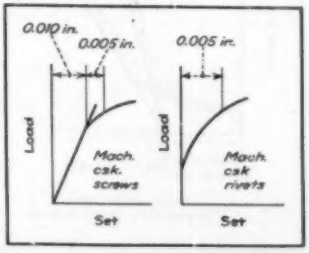



Fig. 5—Load-permanent deflection for machine countersunk screws and rivets.

4. Using this criterion of 0.015 in. for $t/D$ ratio values between 0.45 and 0.9, the following condition exists: One and a half times the load at 0.015 in. set is less than the test ultimate load.

This condition would insure that exceeding the design ultimate allowable would not mean failure of the joint, but would only result in a small increase in hole deformation.

The procedure for determining the design allowables for machine countersunk screws given in Table II for different screw sizes and sheet thicknesses was as follows. The ratio of ultimate load to single shear strength was plotted against $t/D$ ratios. The ultimate load used for plot values was either 1.5 times the yield load at 0.015 in. set or actual test ultimate, whichever was the lower.

Then design curves were determined by dividing the average plot curve for each diameter of screw by 1.15, which is the recommended method of analysis to be followed when data are not sufficient for a statistical study.

The allowables given in Table II for rivets are AP-12 rivet allowables.

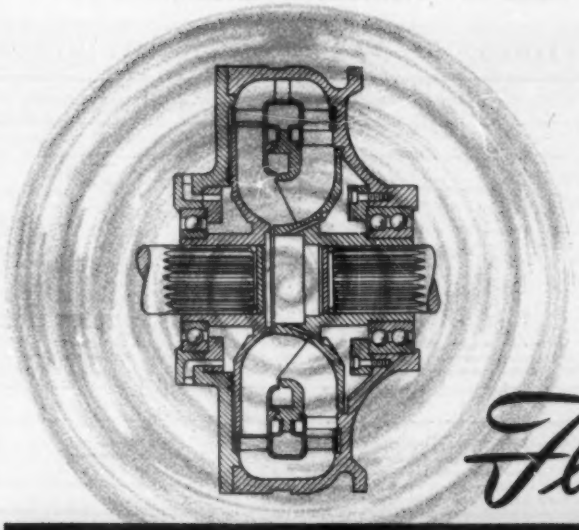
The 70 percent bearing values given in Table II were calculated as follows: Where

$P$ = allowable bearing strength or load on screw, lb
$F_{Br}$ = allowable bearing stress for a desired edge distance, material and thickness as given in ANC-5, psi
$t$ = thickness of sheet, in.
$D$ = screw dia, in.
$P = 0.70\ F_{Br}tD$

If there is a choice of using either screws or rivets, the use of machine countersunk screws should be restricted to sheet-screw combinations with a $t/D$ ratio greater than 0.55 for the following reasons:

1. For $t/D$ ratios less than 0.55, rivet design strength is approximately equal to or greater than screw design strength. (See AP-12 rivet allowables). Also, for $t/D$ ratios less than 0.9 the rivet joint after being subjected to limit load will show a permanent joint deflection of approximately 2.5 percent of the rivet diameter, as compared to 0.020 in. for screws (0.015 in. plus mechanical looseness).

2. Perceptible head tilt and cracking of paint are present for $t/D$ ratios less than 0.5 for machine countersunk screws after being subjected to the aerodynamic requirement of limit load.

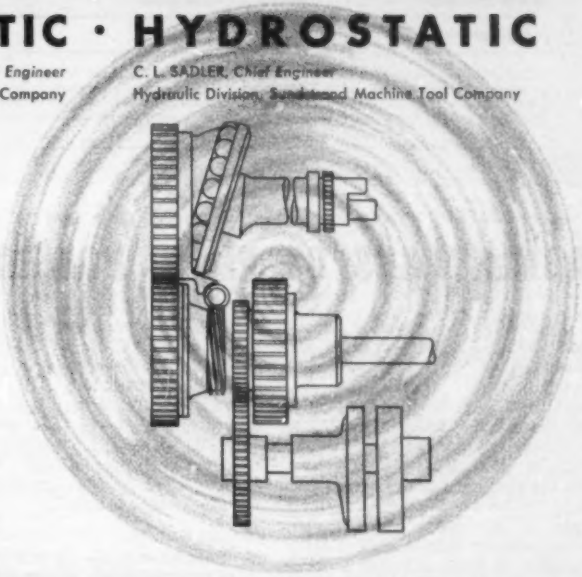


# Fluid Power TRANSMISSIONS

## HYDROKINETIC · HYDROSTATIC

W. F. SHURTS, *Chief Engineer*
Hydraulic Division, Twin Disc Clutch Company

C. L. SADLER, *Chief Engineer*
Hydraulic Division, Sundstrand Machine Tool Company



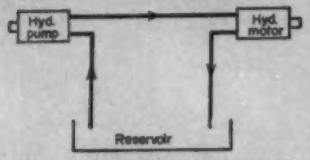
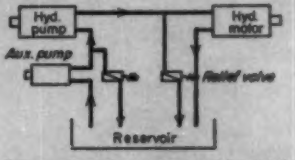
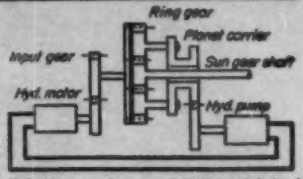
***Types and Modifications***

***Operating Characteristics • Circuit Design • Methods of Control • Applications***

PRODUCT ENGINEERING • MARCH 1950

**Table I—Classifications of Hydraulic Transmissions • HYDROKINETIC • HYDROSTATIC**

## HYDROSTATIC TRANSMISSIONS

| | OPEN SYSTEM | CLOSED SYSTEM | DIFFERENTIAL SYSTEM |
|---|---|---|---|
| *Distinguishing characteristics* |  |  |  |
| | Main pump draws fluid directly from reservoir and hydraulic motor returns fluid directly to reservoir. | Return from the hydraulic motor supplied directly to the main pump intake with a charging pump provided to maintain adequate supercharge at the main pump intake. | Hydraulic pump and motor mechanically interlocked such that primary power transfer is mechanical with hydraulic power transfer superimposed for varying speed ratios. |
| *Operating characteristics* | Infinitely variable speed selectively obtainable in either direction of rotation using either a variable displacement pump or flow control valve with a fixed displacement motor; this arrangement provides a constant torque output over a wide speed range.<br><br>Also, infinitely variable speed in either direction of rotation can be obtained with a constant displacement pump and variable displacement motor, in which case a constant horsepower output is obtained over a narrower speed range. | Same as the open system except that performance characteristics of components in circuit are generally superior, and the accuracy of speed control is usually better than that of an open hydrostatic transmission. For example, a higher volumetric efficiency can be obtained with a piston type variable displacement pump in this circuit than in the open system.<br><br>Flexibility in location of components and functional adaptability of both open and closed systems is excellent. | Smaller pumping elements can be used in this system than in either of the other two for a given horsepower output. Also, this system has a higher overall efficiency throughout the speed range due to direct mechanical power transfer.<br><br>Can be more compactly arranged as a hydrostatic transmission than either the open or closed circuit transmission. |
| *Limitations* | Limited to pumps having ability to prime themselves under all conditions of operation. No practical size limitation, but usually used in smaller horsepower applications than the closed system—although some transmissions are rated at 75 hp or higher. | More complex than the open system and first costs are higher.<br><br>More difficult to adapt to reverse rotation than the open circuit system. | Restricted to single direction rotation and input and output shafts cannot be separately located as in open and closed systems. Also cannot be adapted to multiple output functions as for example one pump selectively driving two or more motors. |
| *Applications* | Feed and traversing drives for machine tools. Auxiliary or main drives for farm machinery, earthmoving equipment, materials handling equipment, plastic molding presses, wire or textile winders, and aircraft components. | Essentially the same as the open circuit system—machine tools, earthmoving machinery, drives for various types of industrial equipment requiring adjustable speed controls, plastic molding presses, and aircraft components. | Primarily in aircraft to maintain constant speed input to 400 cycle generators from varying engine speed, to drive cabin superchargers, or to drive other auxiliaries. Potentially adaptable to machine tool drives but higher cost and greater complexity has hindered this use. |

# ADVANTAGES OF FLUID POWER

Application of variable torque and variable speed transmissions, especially of the rotary type, has reached major proportions only within the past few years. One of the factors that has contributed to a general awakening to the potentialities of such devices has been the requirements of the automotive industry for a continuously variable type of automatic transmission, a requirement that, in almost every instance, is being satisfied through the application of hydraulics. At the same time, manufacturers of other equipment such as farm tractors, road machinery, materials handling equipment, aircraft components, and machine tools have made extensive use of hydraulic power for various types of linear and rotary actuators.

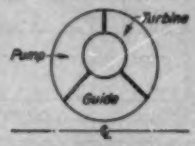
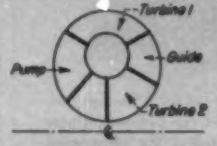
What are the constructional and operational features that account for this increased popularity of fluid power transmissions? What can be gained by their application? Usually several things:

1 A reduction in the size and weight of the transmission equipment. Up to a certain point by increasing the operating pressure or speed, the power output of a fluid system is increased in far greater proportion than is the size or weight. This usually is not true of electrical or mechanical transmissions, and is of considerable importance in many industrial and aircraft applications.

2 Infinitely variable speed, shaft torque, or output power. On machine tool drives or drives for paper mill, rolling mill, or wire drawing equipment, for example, the speed of the driven member may be varied over a wide range and can be held within narrow limits by servomechanism controls. On transportation vehicles, road working equipment and certain industrial machinery, the shaft torque can be varied in proportion to shaft speed. Smooth and stepless acceleration or deceleration may in itself, be of sufficient importance to justify the use of a hydraulic drive.

3 Remote control of driven equipment. With some hydraulic transmissions, the driving motors and pumps may be located independently

## HYDROKINETIC TRANSMISSION

| FLUID COUPLING* | SINGLE STAGE TORQUE CONVERTER | TWO STAGE TORQUE CONVERTER | THREE STAGE TORQUE CONVERTER |
|---|---|---|---|
| ***Distinguishing characteristics*** | | | |
| One set of pumping vanes, and one set of turbine vanes. Has straight radial blades whereas torque converters have sharply curved blades. Can be completely or partially filled with fluid (see text). |  Single stage unit has one pump, one turbine and one guide stage, any one of which can be split to obtain polyphase performance. |  Two-stage four element converter having one pump stage, two turbine stages and one guide stage. Elements also can be single phase or polyphase. | Consists of one pump, three turbine, and two guide stages, any one of which can theoretically be split into two or more elements, same as the other types. |
| ***Types*** | | | |
| Twin Disc Clutch Company, Chrysler, General Motors ("Hydramatic") American Blower, and many others. | White-Schneider, General Motors (Buick "Dynaflow", Chevrolet "Powerglide", and Allison Division), Torque-Schneider, and Borg Warner (for Studebaker and Ford). | General Motors Coach converters' Packard "Ultramatic", and Twin Disc. | Mack, Southern Coach, Aeroscoach, Ran, ACF Brill, Twin Coach, Twin Disc Industrial, ACF Brill of Canada, and GM Coach prior to 1948. |
| ***Operating characteristics and limitations*** | | | |
| Basically a slip clutch using fluid as the driving media. Does not multiply torque—has a one to one torque ratio. When output shaft is stalled, the coupling permit drive engine to operate near speed at which max. torque is developed thus making max. torque available to start the driven members. | Max. torque multiplication on the order of 3 to 1 (about 2.2 to 1 in most automotive applications); one unit has 4 to 1 multiplication, but at a sacrifice in efficiency. Motor usually must overspeed at high torque multiplication, which is one of the basic disadvantages of single stage types. | Torque multiplication higher than single stage (4 to 1). Gives nearly uniform rising engine speed characteristics with decreasing torque multiplication. More difficult to develop than single stage types, but may make single-stage obsolete. | Has inherently greater torque multiplication than other types (6 to 1). Also has uniformly increasing engine speed characteristics with decreasing torque multiplication. Probably represents maximum limit in number of stages since as stages are increased beyond this point, efficiency drops rapidly. |
| ***Applications*** | | | |
| Couplings between electric motors or internal combustion engines in automobiles, tractors, small hoists, winders, auxiliary take-offs in roadworking equipment, aircraft superchargers and auxiliary power drives and literally hundreds of others. | Drives for urban buses, winches, cranes, or hoists, oil well drilling rigs, logging loaders and yarders, drag lines and power shovels, crawler tractors, road scrapers, hauling wagons, off-highway trucks, delivery wagons, gasoline driven factory trucks, railroad switching locomotives, power driven railroad cars, and miscellaneous industrial equipment. | | |

* Not a transmission. Included to show basic difference between torque converter and fluid coupling.

of the machine, only the hydraulic motor being located near the driven member. Particularly on machine tools and aircraft is this an important consideration, but it also is a factor for auxiliary drives of other machinery.

4 Protection of the driving motor against heavy shock loads or overloads. Often the effect of sustained overloads is nothing more than heating of the hydraulic fluid.

5 Simpler construction and ease of operation, often resulting in lower first cost, lower operating cost, and lower maintenance cost than for mechanical or electrical drives.

6 Reversible rotation. With some types of transmissions, the rotation of the driven element can be reversed simply by reversing the direction of the pump or flow of the oil. Gear trains thus are not needed.

## Types of Hydraulic Drives

Hydraulic transmissions are generally classified into two fundamental types: hydrokinetic and the hydrostatic, Table I. A hydrostatic transmission is one in which there is no appreciable change in the kinetic energy of the system; the fluid velocity at input and output of the driven element being the same, and the working energy being obtained through drop in pressure. A positive displacement pump and motor of any of several types can be used.

A hydrokinetic transmission, on the other hand, operates on velocity changes of the fluid, the pressure being maintained practically constant throughout the system. Automotive torque converters are in this category. The main elements consist of a centrifugal pump, one or more reaction turbines and one or more sets of guide vanes. A fluid coupling is somewhat similar in construction to a hydrokinetic transmission except that it has no guide staging and the vanes are straight and radial to the shaft; however, the design and application philosophy is entirely different.

The hydrokinetic type of transmission is as yet unexcelled as an efficient high-horsepower, variable-speed transmission operating from an input power source whose speed can be varied in response to driven load demands. The hydrostatic transmission, on the other hand, provides a means of obtaining efficient transfer of speed and torque from an input source whose speed may be fixed or may vary in some unrelated manner to the desired transmission output speeds and the transmission load.

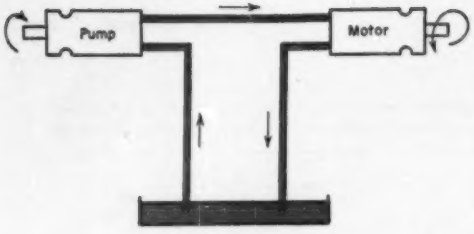



Fig 1—Basic hydrostatic transmission with a constant displacement pump and motor. Speed of the hydraulic motor can be varied only by varying the speed of the pump drive motor; and there is no provision for over-pressure protection of the various elements. These and other disadvantages limit the use of this system; however, such limitations do not apply with suitable auxiliaries in the circuit.

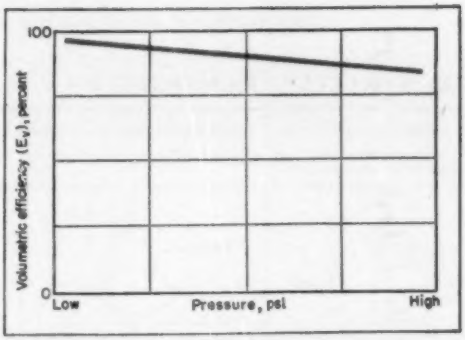



Fig. 2—How volumetric efficiency of a constant speed pump varies with changes in pressure. Slip and cavitation are the losses having the greatest affect on volumetric efficiency, the latter being the one primarily affected by pressure.

# Hydrostatic Transmissions

There are innumerable variations of hydrostatic transmissions just as there are of mechanical, electrical and other types of variable speed transmissions. However, the fundamental components are generally similar. Hydrostatic implies that potential energy is imparted to a fluid and is subsequently converted into useful mechanical energy through the medium of a suitable device. In its barest essence, a transmission can consist of merely a hydraulic pump, a hydraulic motor, and a fluid reservoir with the necessary connecting tubes or passages. This is the simplest type of open system. Because much of the terminology and many of the important design criteria for a complex hydrostatic transmission can be established from this simple combination of elements, it is worthy of detailed comment.

With the proper proportioning of the components, a system as shown in Fig. 1 could provide a continuous unidirectional transfer of energy. If the input speed to the pump is constant and the pump and motor are fixed displacement units, the output speed of the motor remains substantially constant and independent of the driven load. The pressure in the connecting high pressure tube between the pump and the motor is proportional to the driven load, as follows:

$$P = \frac{HP\ \text{Out} \times 1715}{Q\ E_V\ E_T} \qquad (1)$$

where $P$ is the differential pressure between the motor inlet and outlet ports in psi, $HP$ is the hydraulic motor shaft horsepower, $Q$ is the fluid flow to the motor in gpm, $E_v$ is the volumetric efficiency of the motor, and $E_T$ is the torque efficiency of the motor.

An alternate form of this same basic formula is quite useful:

$$P = \frac{2\pi T}{DE_T} \qquad (2)$$

where $T$ is the motor shaft torque in in. lb, and $D$ is the motor displacement in cu. in. per revolution.

These equations assume that the fluid is incompressible. While this is not rigorously true, the compressibility of most hydraulic fluids is considerably less than 1.0 percent per thousand pounds of applied pressure unless excessively aerated or unless very high pressures are involved—a volume change of sufficiently small magnitude to be negligible for all practical purposes. Assuming incompressibility, the degree to which the motor shaft speed will remain constant under varying driven loads depends entirely upon the constancy of the input speed to the pump and the volumetric efficiencies of the pump and motor.

Volumetric inefficiency of a pump generally results from two types of losses; slip and cavitation. All practical kinetic mechanisms have some clearance between the elements in relative motion, and it is the loss of fluid from the pumping section through these clearances that determine the extent of slip or leakage loss. Because clearances usually remain fixed irrespective of operating conditions, the slip loss varies directly with pressure, and is substantially independent of speed. Expressing volumetric efficiency as the ratio of actual delivered volume of fluid to the theoretical or swept volume pumping capacity of the mechanism, it can be seen that the adverse effect of slip loss on volumetric efficiency will be greatest at low input speeds.

Cavitational losses, on the other hand, generally have a converse effect on volumetric efficiency with relation to operating speeds. Cavitation in a pump results from local fluid pressures dropping below the vapor pressure of the fluid, or the pressure needed to keep dissolved gases in solution. Generally, low localized fluid pressures are caused by excessive fluid velocities through restrictive tubes or fittings in the inlet line to the pump or perhaps in the intake ports of the pump itself. The presence of gases in the pump inlet results in only a partial filling of the pumping cavity with liquid, the remainder of the void being occupied by released air and vapor. Not only is the pumping capacity of the unit reduced, but a very detrimental effect upon the physical mechanism may result from the shock loads caused by sudden redesolving of the air and vapors when exposed to full line pressure at the discharge port.

Thus, it is apparent that cavita-

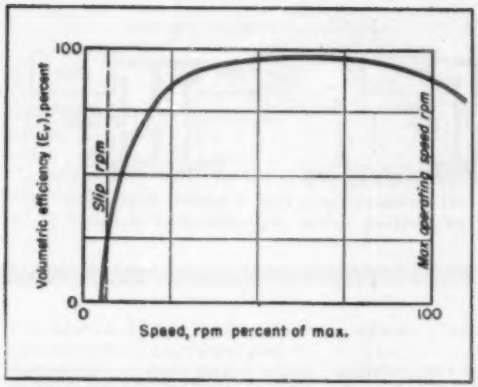



**Fig. 3—How volumetric efficiency of a constant pressure pump varies with changes in speed over the entire range.**

**Fig. 4—Cut-away of piston hydraulic motor. Displacement of this unit is fixed at 6½ cu in. per revolution. Applications include machine tools, roadworking equipment and drives and control elements for aircraft components. This motor has an intermittent horsepower capacity of about 50 hp. and is rated at 30 hp or more for continuous operation.**

tion tends to occur with maximum flow through the pump. In fact, for many types of pumps operating from an open reservoir, it becomes a limiting criterion on maximum operating speeds. Means for circumventing this condition through appropriate circuit design will be reviewed later in the article.

Typical volumetric efficiency curves for a pump operating first over a range of pressures at constant speed, and second, over a range of speeds at constant pressure are shown in Figs. 2 and 3. For a hydraulic motor, the volumetric efficiency curve would be similar except at high speeds. The high inlet pressure supplied to a hydraulic motor prevents cavitation losses; therefore a drop in volumetric efficiency at the higher speeds does not normally occur. Volumetric inefficiencies can play a very important part in the load-speed regulating characteristics of a hydraulic transmission, and are a source of continual concern to the designer of a new mechanism.

It can be seen that the load-speed regulation obtainable for the simplified hydraulic circuit is the product of the volumetric efficiencies of the pump and motor over the range of driven loads and system pressures. Taking into account the effect of input speed variations, a complete network of load regulation curves can be established, based on a knowledge of the probable characteristics of individual components. The addition of flow and pressure regulating devices in the system introduces additional sources of inefficiencies which must be taken into account in practice, but the general procedure for projecting data on load regulation remains the same.

Similarly the power requirements of the transmission can be readily established. Eq (1), in rearranged form provides a direct expression for hydraulic power available at the motor shaft for any given discharge pressure and fluid flow through the motor. To determine pump input-shaft horsepower requirements necessitates introducing only the additional factor of pump torque efficiency, the effect of pump volumetric efficiency having already been included in the determination of $Q$, the fluid flow to the motor. As can be seen from Eq (2), torque efficiency is merely the ratio of theoretical torque required to rotate the shaft of a pumping mechanism having a given displacement and operating against a given differential pressure, related to the actual torque required. If line drop between the pump and motor is appreciable, a proportional correction should also be made in the value used for differential pressure.

In like manner Eq (2) can be rearranged to determine the output and input torques of the motor and pump respectively for any specified system pressure.

## Disadvantages of the Simplified Transmission

The major objection to the simplified transmission undoubtedly is the absence of over-pressure protection. Overloads at the output shaft instantly are reflected in corresponding increases in system pressure, which could reach damaging proportions.

With the addition of a relief valve capable of by-passing fluid from the high pressure line to the reservoir, the maximum pressure can be controlled, thus limiting the maximum torque loading on both the pump and motor, and preventing high line pressures that might burst tubing or component casings. As the quantity of fluid by-passed by the relief valve increases, the speed of the hydraulic motor decreases proportionally and it finally stalls if the overload persists. One of the main attributes of a hydraulic motor, one type of which is shown in Fig. 4, is that, unlike an electrical motor, it is not damaged by extended periods of operation under stall conditions. However, so long as all the fluid flow from the pump passes through the motor, almost all of the available energy is reconverted into useful work; only that small portion unreclaimable due to fluid friction and mechanical inefficiencies appears as heat to increase the fluid temperature. When by-passing of fluid through a relief valve, none of the fluid energy is converted into mechanical energy; all of it is converted into heat which raises the temperature of the fluid in the system. Few hydraulic transmissions have adequate cooling provisions to prevent excessively high fluid temperatures from long continued by-passing through the relief valve. The system accordingly should be designed so that the relief valve will operate only in-

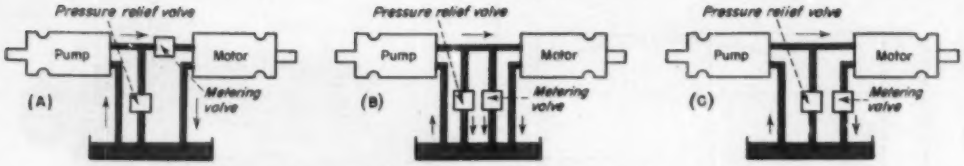



**Fig. 5—Methods of obtaining adjustable speed with a constant displacement pump and motor: (A) metering-in valve type of control; (B) bleed-off metering system; (C) metering-out system.**

termittently for short periods. These are exceptions to this, as will be seen in the further development of the complete hydrostatic system, and there are also certain types of hydrostatic transmissions in which it is inadvisable to incorporate any relief valve at all. Also, there are some applications in which it is essential to limit or regulate the maximum pressure to a closer degree than is feasible with a simple, direct acting relief valve. For these applications, a pilot operated pressure relief valve can be used to advantage.

In the simplified transmission of Fig. 1, the speed of the hydraulic motor is directly proportional to the quantity of fluid supplied to it from the pump; if the pump is driven by a constant speed electric motor—as is quite often the case—the speed of the hydraulic motor is fixed. Therefore, the simplified system must be modified if adjustable speed is a requirement.

## Adjustable Speed Control

The quantity of fluid from a hydraulic pump to a hydraulic motor can be regulated through either of two methods so as to obtain selectively, within reasonable limits, any desired motor shaft speed from stall conditions to maximum rpm. The first of these methods utilizes the same constant displacement pump and motor. A flow regulating or metering valve can be inserted in the high pressure line at any location between the motor and the pressure relief valve, Fig. 5(A). By selecting the desired flow rate through the metering valve, the flow to the motor can be controlled. Motor speed remains substantially constant at the desired setting irrespective of variations in driven load (within the design torque and pressure limits of the system.) The excess flow from the pump, is returned to the reservoir through the relief valve. This type of flow control circuit is generally termed a metering-in circuit.

Two other versions of metering systems are frequently used to better advantage than the metering-in circuit. In one of these, normally termed a bleed-off circuit, the metering valve is installed in a separate return line from the high pressure line, Fig. 5(B). A constant quantity of fluid is by-passed to the supply tank and the remainder, delivered by the constant displacement pump, passes through the constant displacement motor. So long as the input speed of the pump is held reasonably constant, as for example with an electric motor drive, the hydraulic motor speed remains substantially constant. A complete range of output motor speeds can be selectively obtained by adjusting the flow rate of the bleed-off metering valve in inverse relation to the desired output speed.

In general the bleed-off metering circuit has poorer speed regulating characteristics than the metering-in circuit. With the metering-in circuit, the speed regulation is a product of the metering valve flow-pressure regulation characteristic and the motor volumetric inefficiency. With the bleed-off circuit, the additional factors of pump volumetric inefficiency and leakage losses through other valves in the high pressure circuit are introduced. For many applications, close speed regulation is not an essential requirement, and the bleed-off circuit has the advantage over the metering-in circuit of reduced heating of the hydraulic fluid. This can be seen from an inspection of the two systems. In the metering-in circuit, the flow control valve passes only that portion of the pump delivery that is to be used in the motor. For the remainder to be by-passed to the reservoir through the relief valve, the pressure ahead of the metering valve must always be equal to the relief valve setting pressure. This setting must be high enough to take care of maximum load conditions, and under lighter loads, a considerable amount of fluid throttling takes place through the relief valve and also through the metering valve, since the pressure on the motor side of the metering valve is only as high as required to sustain the driven load. With the bleed-off circuit, the system pressure is proportional to load; only under peak load conditions does it reach relief valve setting. This means that the throttling loss through the metering valve by-pass is appreciable less at light loads, and consequently the heating is less severe.

The other type of metering circuit in general use Fig. 5(C), is normally termed a metering-out circuit. It often is applied to machines in which the load may suddenly reverse and tend to drive the hydraulic motor faster than the set speed. A typical example of this in the machine tool field occurs in climb milling, during which the cutter and the work table are moving in the same direction. The uneven force requirements of the work table under the alternate retarding and accelerating forces of the cutter teeth may cause an irregular surface finish pattern if the hydraulic motor is not restrained to a constant speed. The most that either a metering-in or bleed-off valve can accomplish under such circumstances is to reduce system pressure without providing positive braking. If the metering valve is placed on the outlet of the hydraulic motor any tendency of the motor to overrun will cause an immediate increase in the pressure between the motor and the metering valve and a reduction in the pressure ahead of the motor. The resultant reversal of pressure differential across the motor gives a resistance to overrunning. A pressure relief valve would have to be added between the motor and metering-out valve if the driven load torque re-

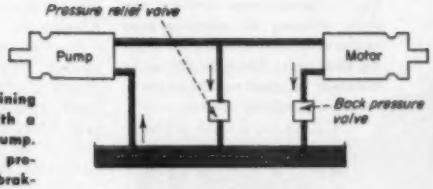



**Fig 6—Method of obtaining variable speed control with a variable displacement pump. The back pressure valve provides reverse differential braking on sudden load reversals.**

versals tended to reach sustained values high enough to produce detrimental over-pressure on the hydraulic motor, but in almost all actual cases, the torque reversal forces are only a fraction of the normal torque, and the additional relief valve is not warranted.

The heat-producing characteristics of the metering-in type circuit are exactly equalled in the metering-out circuit, so its application should be restricted to cases in which either torque reversals are present or closer speed regulation is necessary than can be obtained with the bleed-off circuit.

The principles outlined for a metering valve circuit also apply if a flow regulating device other than a throttling type valve is used. One such alternate device is a separate hydraulic motor, which is used as a flow regulating device by coupling it to the input shaft of the pump to fix its speed. The displacement of the control motor is adjusted to provide the desired rate of flow through the primary hydraulic motor. This method of flow control has the desirable attribute of returning useful work to the system rather than expending it completely as heat. However, there is some question as to whether the heat reduction obtained is worth the greater complication of an additional hydraulic motor, which must be variable in displacement if the transmission is to have adjustable output speeds.

## Variable Displacement Pumps And Motors for Adjustable Speed Control

The other method that can be used to achieve adjustably variable transmission speeds involves the use of variable displacement pump or motor elements. If a variable displacement pump is used instead of a constant displacement pump, any desired motor speed can be achieved by merely changing the proportional displacement of the pump with relation to that of the motor. The torque and pressure characteristics of the system can be directly computed in the manner indicated for the transmission shown in Fig. 1. The speed regulation of the system is the product of the volumetric inefficiencies of the pump and motor plus leakage loases through any valves in the high pressure circuit. A high pressure relief valve is generally included in the system to provide protection against overloads, but its operation is usually intermittent since the pump supplies only that quantity of fluid and that pressure required to sustain the desired motor shaft speed and load. Heating in the system is quite low.

It is this characteristic of lower mean flows and pressures in the system with an attendant high operating efficiency and low rate of heating of the operating fluid that makes the variable displacement pump circuit especially attractive for some transmission applications. Many users of hydraulic transmissions object to the maintenance problem introduced with the addition of a heat exchanger in a system; also there are instances where it is impractical to incorporate a heat exchanger at all. For such applications, the variable displacement pump circuit offers the best opportunity for achieving a satisfactory installation. This of course pre-supposes that the transmission duty cycle is sufficiently severe to pose a problem for any of the available types of speed control. If, on the other hand, the duty cycle is light or the inherent heat radiating capacity of the transmission is adequate to maintain reasonable fluid temperatures and viscosities using a metering type control, the initial cost for procuring the metering circuit usually is less than in the case of the variable displacement pump circuit.

The method in which the problem of sudden load reversals of the type described in connection with the metering-out type circuit is handled with the variable displacement pump circuit is of interest. For such applications, it is customary practice to supply a back-pressure valve in the outlet of the hydraulic motor, Fig. 6. This provides an instantaneous reverse differential braking force in the same manner as the metering-out valve. The magnitude of the required back-pressure setting depends upon the specific application but in most machine tool applications experience has shown that the overrunning force is rarely more than 20 to 30 percent of the normal load torque, and the back pressure setting can be proportionally low.

Another method of obtaining selective speeds is by means of a constant displacement hydraulic pump and a variable displacement hydraulic motor. Obviously this combination is practical, and it exhibits some interesting characteristics. To meet requirements of good speed regulation and constant torque output over a wide range of output speeds, it is economically a poor selection as compared with either the variable displacement pump and constant displacement motor or one of the metering type circuits. To appreciate this, it should be remembered that the output torque capacity of a hydrostatic transmission is proportional to the displacement of the hydraulic motor and the system pressure. If a given torque is to be transmitted and the maximum system pressure is limited by design considerations of the pump, motor, and other system components, then the minimum displacement of the hydraulic motor is also fixed. Any reduction in output speed with the variable displacement motor must necessarily come from increasing motor displacement. This means that a motor with a large ultimate displacement is required if a reasonable output speed range and adequate high speed torque capacity is desired. To meet the same requirements with the converse combination of a variable displacement pump and constant displacement motor would require elements with ultimate capacities no greater than the minimum required variable displacement motor displacement. The economics of this are obviously in favor of the variable pump arrangement.

Also, the variable displacement motor is limited in the range of dis-

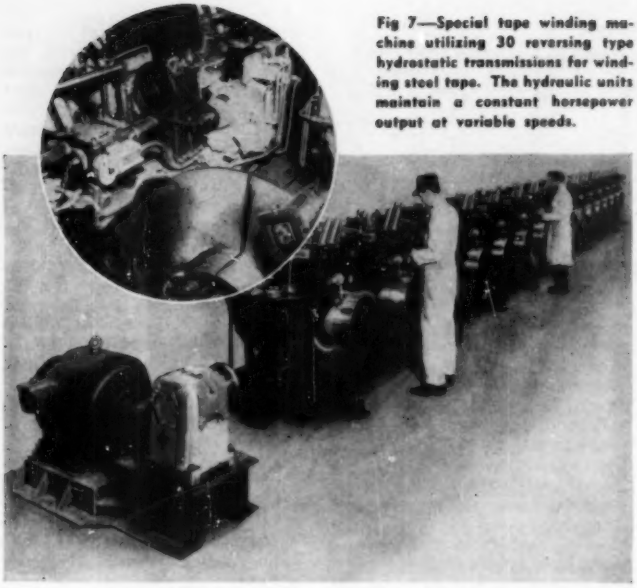


**Fig 7—Special tape winding machine utilizing 30 reversing type hydrostatic transmissions for winding steel tape. The hydraulic units maintain a constant horsepower output at variable speeds.**

placements through which it can be operated with reasonable efficiency. At low displacement settings the mechanical translation from reciprocating to rotary motion in the motor becomes relatively inefficient, and motor manufacturers generally limit the range of operating displacements to an approximate 4 to 1 ratio. There is no similar limitation on the variable displacement pump; the translation from rotary to reciprocating motion can be efficiently accomplished through the complete range from zero to maximum displacement.

There are interesting applications of the fixed displacement pump and variable motor combination, however, especially when a torque and speed characteristic similar to a series wound electric motor or a hydraulic torque converter is required. For such applications, the variable displacement motor operating with a fixed displacement pump is ideal. The motor displacement is made automatically variable in inverse proportion to system pressure. As the driven load increases, tending to slow the motor and increase system pressure, the displacement of the motor increases, with a corresponding increase in applied torque. Conversely as the driven load decreases, motor displacement automatically decreases with a corresponding increase in shaft speed. In net effect this provides substantially a constant horsepower output with as high an output speed as the torque requirements permit. Already extensively applied in low horsepower applications such as winding equipment, Fig. 7, this same basic combination of elements may some day prove to be an interesting competitor to the electric traction motor and the hydrokinetic torque converter in the high horsepower ranges.

So far in this analysis of basis system components, the pump and motor circuit characteristics have been considered with respect to over-pressure protection and speed regulating provisions. The next obviously desirable feature is directional control, or in other words, the ability to reverse the rotation of the hydraulic motor during operation. To do so requires only the shifting of applied pressure differential from one of the motor ports to the other. The basic circuit would appear as shown in Fig. 8 when modified to include directional control. As might be expected there are a large variety of types of directional control valve arranged for electrical, hydraulic or manual operation.

An alternate method for producing reversibility by means of a pumping mechanism designed to reverse its action and consequently the direction of flow through its ports, will be discussed later. To utilize a reversing mechanism of this type requires a different method of introducing hydraulic fluid from the reservoir. Before considering this type of circuit it may be of interest to briefly study the physical limitations of components currently available for use in the transmissions already discussed.

## Types of Pumps, Motors And Valves

Three types of positive displacement pumps are in general use, Table II. Of these, by far the most common is the gear pump. Most manufacturers utilize conventional involute spur gears for the pumping members, with tooth design arranged with as low a pitch and as large a pressure angle (30 deg) as possible to achieve maximum swept volume in a minimum of space As might be expected, a number of specialized gear profiles are marketed in pumps, mostly aimed at minimizing noise which is likely to be an accompaniment of high pressure hydraulics regardless of whether a gear, piston, or vane pump is used. Noise elimination is in itself a major subject for discussion; briefly, the designer should make sure that faulty or restricted inlet conditions are not present to promote cavitations or air entrainment in the fluid. Also, addition of leak-off slots in the high pressure cavity to prevent fluid from being

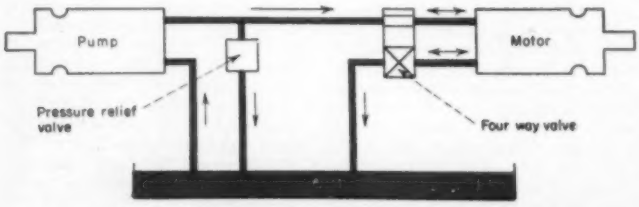



**Fig 8—Placing a four-way valve between the input and output ports of the hydraulic motors adds selective reversibility to the basic hydrostatic system.**

trapped in the gear mesh is generally considered beneficial in gear pump design.

One restriction on the use of gear pumps is that they do not lend themselves to variable displacement construction. However, this factor is of little importance in hydrostatic transmission applications involving relatively intermittent high pressures, or applications in which the driven load demands remain substantially constant under all conditions of operation.

Vane type pumps have found considerable application in certain fields, of which the machine tool industry is perhaps the most prominent. Vane pump characteristics are quite similar to the gear pump from the standpoint of volumetric and torque efficiencies and useable capacity ranges. In the larger capacities, the vane pump has excellent swept volume or displacement in relation to its size. Most vane pumps depend upon centrifugal force to hold the vanes firmly against the outer shell. This limits the minimum speed at which the pump can be operated. Since it is generally desirable to operate the pump element at as high speeds as practical to reduce the require pump displacement to a practical minimum, this low speed limitation is rarely a handicap. It can become critical in some types of applications in which the source of power is an internal combustion or other type of engine that operates over a wide speed range.

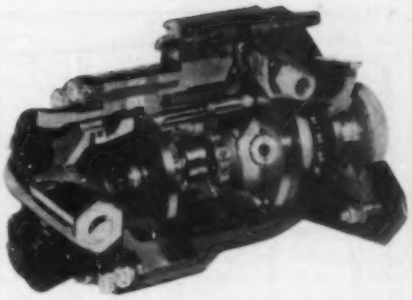


**Fig. 9—Cut-away of variable-volume piston type fuel pump. Although this unit is a gasoline pump for jet engines, the construction is similar to a variable displacement industrial pump with a servomechanism control for positioning the wobbler assembly as a function of an input signal.**

Because of its greater complexity and additional cost, the piston pump Fig. 9 is generally more restricted in application than either the gear or vane type pump, but higher volumetric and higher overall efficiencies are achieved with it than with any other type known today. This can be of considerable significance when good speed-load regulation or low power and heat rejection losses are important.

Most piston pumps can be adapted to variable displacement operation, and this fact, coupled with the excellent performance characteristics of the piston pump, has largely accounted for its use for high performance hydrostatic transmissions.

## Types of Hydraulic Motors

Hydraulic motors include both linear and rotary actuators. In the preceding discussion of circuits, rotary actuators were assumed throughout, but the basic principles remain essentially the same in the case of linear actuators. The design of hydraulic cylinders has steadily improved over the past few

**Table II—System Components for Hydrostatic Transmissions • PUMPS**

| OPERATING DETAILS | GEAR PUMP | VANE PUMP | PISTON PUMP |
|---|---|---|---|
| Principle of Operation | The pump consists of meshing gears surrounded by a housing. As the gears rotate, hydraulic fluid is trapped in the clearance between mating teeth and boosted to higher pressure as the clearance is decreased. The pump can have external or internal meshing gears with spur, helical, herringbone, or special tooth forms. | This pump consists of a housing and a rotor in which vanes slide in slots cut radially in the rotor face. The vanes are held against the housing by centrifugal force, springs or hydraulic pressure. As the rotor turns eccentrically in the housing, the fluid is trapped between the vanes and pumped to higher pressure as this space decreases in volume. | Three basic types are available: one in which the pistons are set radially in the rotor and are driven by eccentric rotation of the rotor; one in which the pistons are driven by crank operated rocker arms, and one in which either the pistons or a face plate rotate eccentrically or gyrate around the drive shaft to drive the pistons, the well known wobbler pump being an example. |
| Advantages | Most common type of pump because of low initial cost and simplicity of construction. Can be obtained in wide range of operating pressures and capacities. Can be made suitably efficient at low speeds, although operates best at high speeds. | Comparable to gear pump in most respects, but can be adapted for variable displacement. Particularly compact in size in high capacity ranges. Generally lower in first costs than piston pumps. | Higher overall efficiency than other types. Can achieve higher fluid pressures and more accurate control of discharge volume than with gear or vane. Most types lend themselves well to variable displacement construction. Output adjustment can be selectively arranged for manual or automatic control. |
| Limitations | Does not lend itself to variable displacement construction. Overall efficiency is lower than piston type. | More limited in maximum permissible speeds and pressures than either gear or piston types. Higher initial cost than gear pump. | Greater initial cost and complexity than other types, so is used only when operating characteristics are of greater importance than cost. |
| Approximate Max. Speed Range | 1200 to 1800 rpm for industrial applications. 4000 to 9000 rpm for special aircraft applications. | 1,200 to 1,800 rpm for industrial applications. Up to 3,000 rpm for special aircraft applications. | 1,200 to 1,800 rpm for industrial applications. Up to 5,000 rpm for some special aircraft applications. |
| Approximate Max. Pressure Range | 1,000 to 1,500 psi for industrial applications. Up to 3,000 psi for some aircraft applications. | 1,000 psi for most applications. Up to 2,000 psi in two-stage design for some uses. | 1,000 to 2,000 psi for industrial applications. 3,000 to 5,000 psi for special aircraft and industrial applications. |

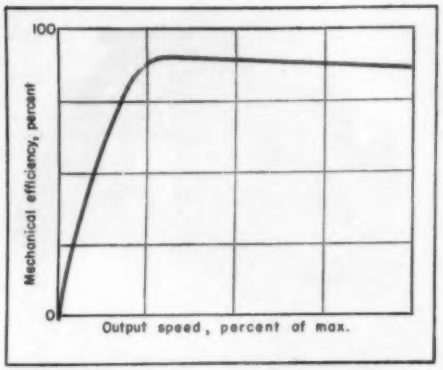



Fig. 10—Characteristics mechanical efficiency curve for a hydraulic motor operating under constant pressure. The mechanical inefficiency establishes the stall speed.

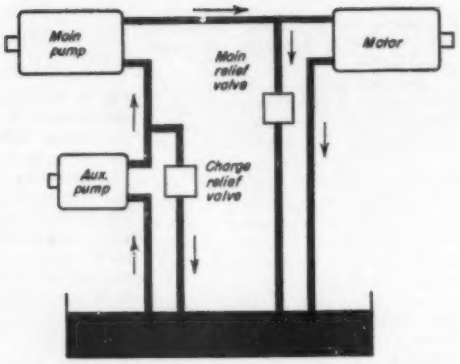



Fig. 11—One type of closed circuit system. Good speed control is obtained and additional power is available for peak functions, such as rapid traversing of machines.

years, particularly with respect to packing and seals so that today dependable, long life cylinders for 3,000 psi or higher pressure duty are taken as a matter of course.

Rotary type hydraulic motors, Table III, have about the same operating characteristics as their pump counterparts, with certain limiting exceptions. It was noted that a hydraulic pump is limited in its ability to deliver oil under high pressure at low speeds because of the constant slip or leakage losses that occur at the pump clearances. It is possible to project from test data an approximate speed at which the pump delivery would be zero for any particular discharge pressure and fluid viscosity. This speed is generally termed slip rpm, and was indicated in Fig. 2. Mechanical inefficiency is also present under these conditions, but if an adequate power source is available, it does not affect slip other than by the introduction of additional heat and consequent change in fluid viscosity. In actual practice, it is inadvisable to operate a pump at speeds approaching the slip speed because of the heating of the hydraulic fluid and pumping mechanism resulting from inefficient operation. This, then, establishes a band of minimum operating speeds for any given hydraulic pump.

In a hydraulic motor, however, low speed operation is frequently of considerable importance. The volumetric inefficiency of the motor is, generally speaking, equivalent to that of its pump counterpart, but just as the mechanical inefficiency of a hydraulic pump has no fundamental relation to its slip rpm, so the volumetric inefficiency of a motor represents only additional fluid that must be delivered from the system to sustain rotation. By like reasoning, it is apparent that mechanical efficiency is all important in establishing the low speed characteristics of a hydraulic motor. The characteristic curve of mechanical efficiency for a hydraulic motor is shown in Fig. 10. As the mechanical efficiency of the motor decreases at progressively lower operating speeds, a tendency to irregular or jerky rotation appears and the motor finally stalls out abruptly. However, this full torque stall speed can be made as low as 1.0 rpm, and the minimum speed for smooth operation can be less than 5 rpm. On the other hand, in lower cost motors used on non-critical applications, the full torque stall speed may be as high as 200 rpm or more.

Under actual stall conditions, the output torque of the motor varies as a function of the angular position of the shaft. This can best be visualized by considering a piston type motor, although the same type of variation will occur with a gear or vane motor. As the shaft is slowly rotated through one revolution, the number of pistons exposed to high pressure varies with a proportional change in output torque.

After the motors start rotating, the magnitude of torque pulsation as a function of angular position normally decreases slightly, primarily because the running friction is less than the static friction occurring during stall. In any case, the magnitude of pressure pulsation is small unless the motor is poorly designed. It is possible to write equations for the theoretical pulsations that will occur but actual oscillograph traces frequently show poor correlation with theory, due perhaps to unpredictable pulsations and varying friction torques.

Although slip speed of a hydraulic motor does not affect low speed motor performance in terms of smooth rotation and stall speed, it can be important in terms of speed regulation under varying output loads. With either the metering circuit or the variable displacement pump circuit, the control maintains a substantially constant rate of fluid flow to the motor. If the volumetric efficiency of the motor is poor, the resulting speed regulation will be poor, particularly at speeds approaching slip RPM. For critical applications it is of course possible to obtain a direct sensing of output speed and provide a proportional correction to the flow control setting. Since it is possible to obtain hydraulic motors with extremely high volumetric efficiencies and low slip RPM's for critical applications, this additional control complexity is rarely warranted.

## Hydraulic Valve Design

Hydraulic valve design generally follows conventional practice. One of the major considerations is the condition of limiting velocities through passages, ports, and asso-

ciated lines. For these, a rule of thumb criterion of 12 to 15 fps is generally accepted in the industry. There are, obviously, occasional exceptions to this limit, and fluid velocities of thirty fps or more sometimes can be used successfully and even advantageously. Also, the 12 fps criterion applies only to components and lines under pressure. On pump intake lines, local velocities in excess of 6 fps should be avoided because of the previously discussed relationship of cavitation to high velocities. While reasonably low velocities are desirable and often even imperative for satisfactory operation of valves, it may be inadvisable to use overly large valves for a given flow requirement. Aside from obvious space and economic considerations, the large valve may have adverse internal leakage characteristics as compared with its smaller counterpart and may not exhibit as good minimum flow stability.

One of the most significant recent trends in hydraulic valve design has been the substitution of panel mounted valves with pressure-sealing gasketed ports for the conventional threaded port valve. With the panel mounted valve, it is possible to remove a defective assembly and substitute a replacement unit in a few minutes. Since no lines have to be broken, there is no danger of damaging a thread or a flare, or otherwise causing a leak in the circuit.

## Closed Hydrostatic Systems

In the hydrostatic circuits that were previously discussed, the pump drew all of its fluid directly from the reservoir, and all of the flow from the motor was returned to the reservoir. This type of circuit generally is termed an open circuit system, correctly implying essentially atmospheric pressure in the pump intake line, with the pump producing the negative differential pressure required to induce flow into the pumping cavities. With some types of pumps, it is desirable or necessary to provide greater than atmospheric pressure at the inlet to obtain good operation —a requirement incompatible with the general arrangement of the open circuit system. This can be accomplished by inserting an auxiliary supercharging pump between the reservoir and main pump, Fig. 11. The auxiliary pump must have a capacity at least equal to the main pump capacity, and in actual practice usually is at least 10 percent higher. Also, a relief valve is required in the line between the auxiliary pump and the main pump intake to limit the maximum supercharging pressure.

One application for closed circuit systems is on machine tools. Since it is usually desirable to return the machine to the starting position more rapidly than it advances during the working stroke and it is uneconomical to specify a feed pump large enough to accomplish this rapid traversing function, an auxiliary gear or vane pump is almost always installed for this purpose. The circuit for a high production profile milling machine, Fig. 12, is an illustration. There are two basic hydraulic circuits on the machine, each interlocked to achieve the desired sequential operation, Fig. 13. These two circuits operate three elements of the machine.

The "head cylinder" is used to move the cutter and tracer mechanism into position and hold the tracer against the master cam. The "quill cylinder" controls the vertical movement of the cutter, moving it in or out of position and regulating the travel of the cutter into the work. The constant displacement fluid motor rotates the work table and master cam.

A large number of operating

**Table III—System Components for Hydrostatic Transmissions • MOTORS**

| OPERATING DETAILS | GEAR MOTOR | VANE MOTOR | PISTON MOTOR |
|---|---|---|---|
| Principle of Operation | Same as gear pump except flow is from high pressure side to low pressure side. As a motor, the bearing loads should be balanced for best efficiency. | Same as vane pump except flow is from high pressure to low pressure side. | Same as for piston pump except that flow is from high pressure to low pressure side. To eliminate torque pulsations, an odd number of pistons usually is used unless the total number exceeds 11, in which case the variation is so small as to be negligible. |
| Advantages | Least complex and therefore least expensive. | Large swept volume per revolution. Used for applications requiring large torques at relatively low speed. | Equal in all criteria of hydraulic motor performance. |
| Limitations | Tends to be quite noisy in operation. Stall speeds tend to be quite high. | Auxiliary means rather than centrifugal force must be used to hold vanes in position at low operating speeds. Started only to a limited extent for industrial use. | Higher first cost than other motors. |
| Torque Efficiencies | As high as 95 percent in many applications. | Similar to gear motor. | 90 to 95 percent obtainable throughout much of operating range. |
| Stall Torques | Up to 75-85 percent of theoretical. | Same as gear motor. | As high as 95 percent of theoretical, and 90 percent of theoretical is quite common. |
| Speed, pressure, and capacity ranges | Same as gear pump. | Same as vane pump. | Same as piston pump. |
| Typical Applications | Material handling equipment, conveyors, road and farm machinery. | Earthmoving equipment, conveyors, road machinery. | Machine tools, processing equipment, earthmoving and road machinery, aircraft, naval and ordnance mechanisms. |

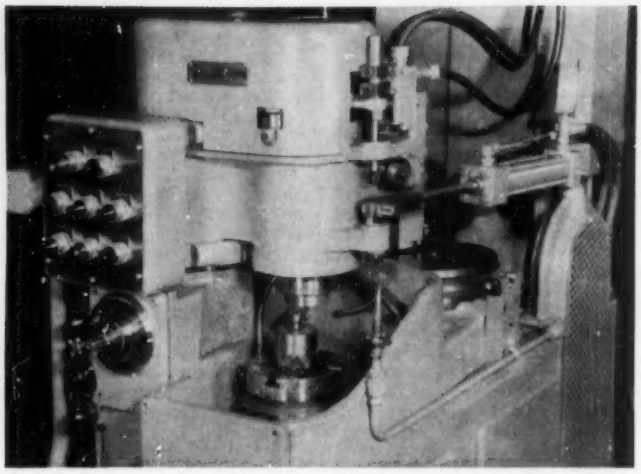


**Fig. 12—Closed hydraulic systems are used on this high-production profile milling machine to move the cutter and tracer mechanism into position, control the movement of the cutter, and rotate the table and master cam.**

sequences can be obtained from these circuits. For brevity, only one of these sequences will be described. Considering first the action of the head and quill cylinders in this particular sequence, it is desired to move the head cylinder in towards the work at a relatively slow rate and then maintain a light force to hold the tracer against the cam. Immediately thereafter, the quill cylinder is moved downward at a slow rate, feeding the cutter into the work. To accomplish these functions hydraulically, a fixed displacement pump, protected against over-pressure by a relief valve is used, and a metering valve and by-pass valve are hooked in parallel to two solenoid operated four-way valves. By closing by-pass valve *L*, metered rates of flow are fed into each of the cylinders in sequence through four-way valves *E* and *F*. Valve *E* is energized to actuate the hydraulic cylinder inward and the pressure reducing valve in the line limits the applied pressure against the master cam. During this period, valve *F* maintains a positive pressure on the return side of the quill cylinder holding the cutter out of position. As soon as the head cylinder is in position, four-way valve *F* is energized, moving the quill cylinder into position. The rate of movement of both cylinders is controlled by the metering valve setting and can be adjusted at will to accommodate various types of parts.

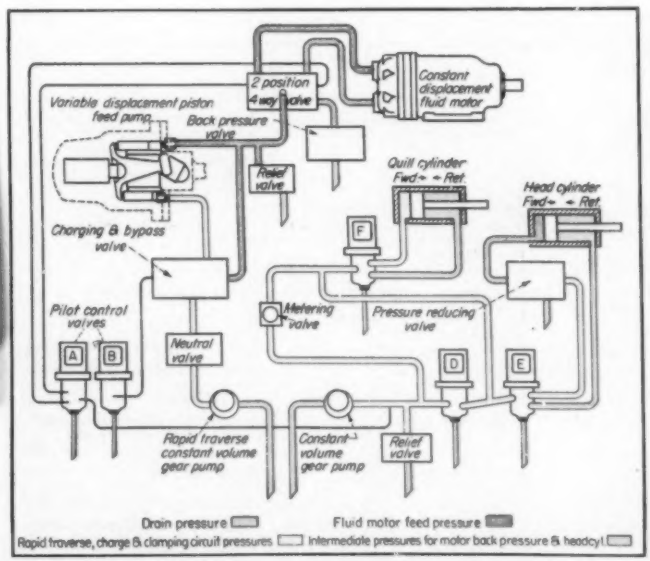
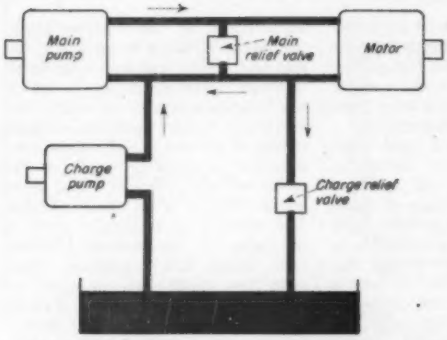



**Fig. 13—Hydraulic circuit for the profile milling machine. Two basic circuits supplied by one pump operate the three elements on the machine.**

At the completion of the work cycle, it is desirable to retract the cutter and tracer mechanism rapidly to permit insertion of the next piece. By-pass valve *D* is opened, eliminating the restrictive action of the valve and permitting the full capacity of the pump to pass to the cylinders. At the same time, the four-way valves are energized in sequence for the reverse direction, giving a rapid return stroke on each cylinder.

As soon as the head and quill cylinders are in position, the work is rotated through the desired arc by means of the fluid motor. A variable displacement piston pump is used to accomplish this and provide selective speeds of rotation. An auxiliary constant-displacement pump provides charging pressure at the intake of the piston pump and returns the table to the starting position. The relief valve in the system prevents excessive pressures in the circuit; the two-position four-way valve controls the direction of rotation of the fluid motor, and the back-pressure valve keeps the rotation of the fluid motor uniform under the load reversal torques that are encountered during this type of milling work. The combined charging and by-pass valve regulates the charging pressure to the piston pump and shunts the flow of the rapid traverse pump directly to the fluid motor for the return cycle.

Thus, in this application, the auxiliary pump serves a dual function. However, when there is no need for an auxiliary pump other than for supercharging the piston pump, a generally preferred method is to couple the return line from the hydraulic motor and any relief valves in the main circuit to the



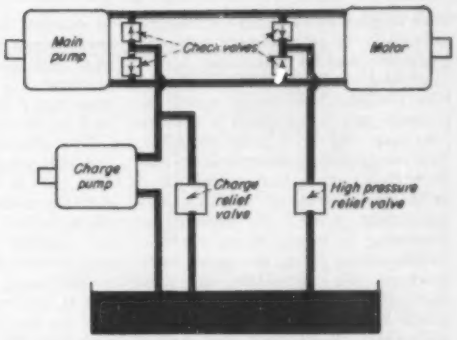




**Fig. 14 (Left)—Another type of closed circuit system. This is preferred to the system shown in Fig 11 when the auxiliary pump is needed only for supercharging. Fig. 15—Closed system for use with a reversing pump.**

piston pump inlet, and provide a small charge pump and charge relief valve to keep the main circuit completely filled with fluid. This circuit, Fig. 14, has some excellent attributes for some types of applications, although its use obviously should be limited to those cases in which the added complication of a special charge pump and charge relief valve is warranted.

In the closed circuit system, the pressure maintained in the pump intake line by the charge pump is controlled by the charge relief valve setting. This setting obviously should be as low as is consistent with good operation to limit the power absorption of the charge pump and to make available the maximum output power, since hydraulic motor power is proportional to the differential pressure, which is in part a function of the return line pressure. A pressure as low as 5 psi might be sufficient in some instances to force fluid through restricted lines and port openings and prevent cavitation, but there are other cases in which 200 to 300 psi is required, either by the pump supercharging requirements or to maintain an adequate back pressure on the motor for load-reversal braking.

The capacity of the required charge pump is determined by either of two considerations. If the heat produced by the main system is great enough to require auxiliary cooling means, it is generally advisable to place the heat exchanger in the external circuit, normally between the charge relief valve and the reservoir, to avoid having the heat exchanger under high pressure. This means that the charge pump capacity must be adequate to insure a sufficient interchange of oil in the main circuit to maintain specified main circuit oil temperatures. The amount of heat introduced by the charge pump is negligible in relation to the main circuit losses because of the low charge circuit pressure. On the other hand, if the heat radiating capacity of the system inherently is great enough, or if a high pressure heat exchanger is installed directly in the high pressure circuit, the capacity of the charge pump need only be large enough to replenish the oil lost from the main circuit through leakage. Since the leakage losses of piston pumps and motors normally used in this type of circuit are slight, the charge pump capacity can be small, perhaps 10 percent of the main circuit flow.

As this latter requirement normally governs charge pump size, the power absorption of the charge pump is insignificant in relation to the transmitted power of the overall transmission. In applications in which load reversals can occur and reverse power braking is desired, the closed circuit system can accomplish this braking function equally as well as an open circuit system having either a metering valve or a back pressure valve.

To get away from a separate input shaft and driving means, the charging pump often is built into the main pump structure. Also, the charge relief valve frequently is contained in the internal porting of the main pump housing.

As previously pointed out, the use of a high pressure relief valve is inadvisable in certain types of hydrostatic transmissions. This apparently incongrous condition is peculiar to closed circuit systems and occurs in the design of close-coupled, high-performance aircraft transmissions with small oil reservoir capacities. In such a transmission, the heat rejection of the system is low so long as the hydraulic motor is absorbing the full output of the pump. However, with a relief valve installed, all of the system energy goes into heat in the event the motor stalls, and damagingly high temperatures may be reached in a short time. Under such circumstances, it is advisable to omit the relief valve and design the mechanism for over-pressures. Then, as an ultimate limit on maximum applied pressure, a shear section or other permanent disconnect means can be incorporated in the input shaft. If, as is general in such transmissions, a variable displacement pump is used, it is easy to add an overpressure servo control that will reduce the pump displacement under excessive motor torques, thus accomplishing the same function as a direct-acting relief valve but without the attendant adverse heating of the fluid.

The predominant application of closed circuit systems is for piston-type transmissions, particularly those transmissions in which excellent performance is a primary criterion. A completely reversible transmission providing full control of rate of rotational speed in each direction from zero to maximum speed is an example. As previously mentioned this could be accomplished either through the use of a directional control valve or a vari-

able displacement pump. Although adequate for most circuits, the directional control valve may introduce undesirable surge pressures in the system under rapid speed reversals, and it is difficult to achieve the same degree of speed control at low motor speeds, approaching stall in each direction, that is obtainable with the reversing variable displacement pump. To accomplish reversing by means of the variable displacement pump, the pump must reverse the direction of flow through its ports with the input shaft continuing to rotate in one direction. Both axial and radial type piston pumps can be made to do this at the expense of some complexity. In essence it requires reversing the inlet and outlet valving in relation to the pumping stroke. Each pump manufacturer has his own particular method for accomplishing this, and it would require more space than is warranted here to describe the several methods.

The external circuit used with the reversing pump is shown in Fig. 15. It is essentially a closed circuit system with a pair of check valves added so that the flow from the charge pump automatically enters the low pressure intake line to the pump regardless of which line is carrying the high pressure flow to the motor. Similarly the high pressure relief valve line is tied in with the main lines through check valves to automatically provide overpressure protection for either direction of rotation.

# Differential Hydrostatic Transmissions

One further type of hydrostatic transmission is worthy of comment. This type of transmission, normally referred to as the differential transmission, Fig. 16, is largely an outgrowth of the basic variable displacement pump and motor combination. The pump and motor are closely coupled in a cylinder block assembly, which in turn is contained in bearings so that the block assembly can rotate. The input shaft is geared to this block assembly so that the block rotates at a fixed relation to the input speed. The pump is a variable displacement unit with the displacement selectively controlled by the positioning of the pump wobbler plate. The pump wobbler has sufficient movement to provide complete reversibility in output flow. The motor is a fixed displacement unit with its output shaft driving the load through a pair of fixed ratio gears. The hydraulic circuit, Fig. 17, is a closed circuit system with a charge pump and charge relief valve supplying fluid from the reservoir to the main pump and motor circuit. A scavenger pump picks up the leakage oil and by-pass oil from the charge relief valve and returns it to the reservoir.

If the pump wobbler is in the neutral or zero stroke position and the cylinder block is rotating opposite to the direction of rotation of the input shaft, the pump pistons rotate with the cylinder block but do not reciprocate because of the neutral wobbler position. The motor pistons also rotate with the cylinder block but theoretically cannot reciprocate because of the hydraulic lock produced by the nonreciprocating pump pistons. (In actual practice there is slow reciprocation of the motor pistons due to the slip loss of the pump and motor.) Thus, the motor wobbler must rotate at substantially the same speed as the cylinder block, the slight variance being due to the slip loss. This produces a straight-through drive condition in which the hydraulic circuit provides only a reaction force to prevent reciprocation of the motor pistons and consequently a reaction torque on the motor wobbler, without actual work being accomplished hydraulically. The absence of hydraulic work is indicated by the absence of fluid flow under this condition, other than the small flow required to counteract slippage losses. Practically speaking, then, the energy transfer is mechanical. The power from the input shaft is transferred through the housing and motor shaft assembly to the output gear.

As the pump wobbler is moved out of the zero stroke position to provide positive flow, the motor wobbler must rotate at an increased rate, which in turn is proportional to the additive reciprocating movement of the pistons. Under this condition, the motor wobbler is rotating faster than the cylinder block and flow work is being added to the mechanical energy transfer.

Similarly, when the pump wobbler is moved out of zero stroke position in the reverse direction, the hydraulic lock between the pump and motor pistons is partially removed, and under the influence of the reaction torque of the motor wobbler, the motor pistons reciprocate at a rate that is proportional to the change in pump displacement. The direction of flow is then from the motor to the pump and the speed of the motor wobbler decreases proportionally with the displacement change.

There is an apparent interchange

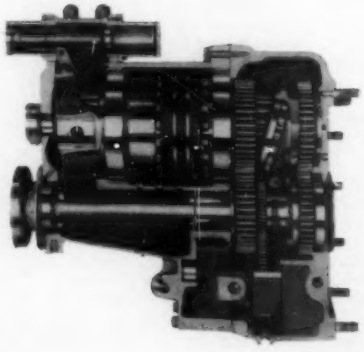


**Fig 16—A differential transmission suitable for 50 hp continuous output and 100 hp for intermittent periods. This transmission functions as a constant output speed drive, maintaining constant horsepower over a range of input speeds. Its weight-power ratio is slightly in excess of 1:1.**

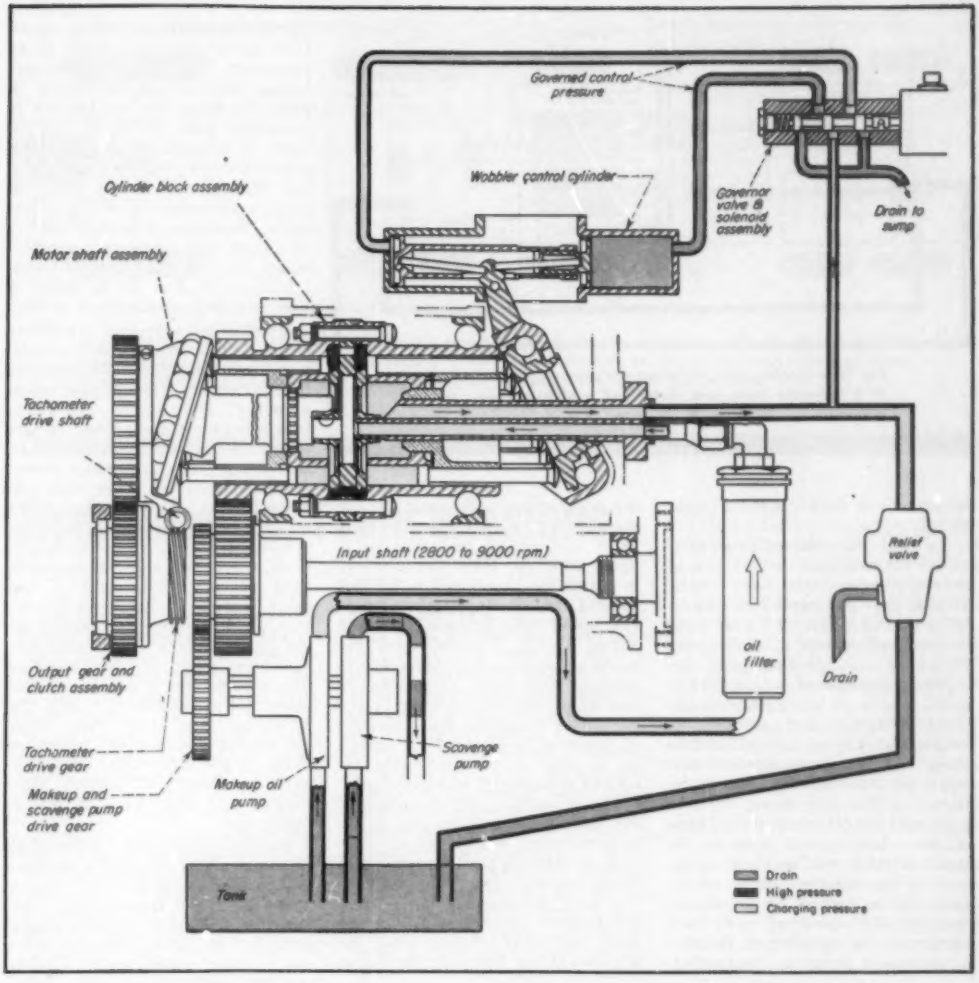



**Fig 17—Circuit for differential system shown in the previous illustration. Displacement of the pump is controlled by the position of the wobble plate.**

of functions between the two hydraulic elements in that the fixed displacement "motor", which is still delivering mechanical output shaft power, simultaneously returns hydraulic energy to the variable displacement "pump". The flow work is introduced in a negative sense in relation to the mechanical energy transfer.

It is interesting to note that the connecting passage between the pump and motor continues under high pressure even though the direction of flow reverses. Similarly, the charge circuit remains at low pressure in spite of flow reversal. On review, however, it is apparent that no reversal in pressure should occur since the output torque does not reverse during the transition. In the straight reversing pump and motor transmission without differential action, the reversal of flow is accompanied by a reversal in the relative pressure levels in the hydraulic lines or passages. For some hydraulic mechanisms, this distinction can have a significant influence on the design of the system—especially on the hydraulic valves and piping.

Mathematically, the relation between the hydraulic power developed in the differential system and the output horsepower can be expressed by:

$$P_H = P_o\ (1-N_i)/N_o$$

where $P_H$ is hydraulic power, $P_o$ is output power, $N_i$ is input or cylinder block speed in rpm and $N_o$ is motor wobbler speed in rpm. This equation is useful for general inspection purposes only since it does not take into account the inefficiencies of the transmission. However, it does show the absence of hydraulic horsepower at the straight-through drive position, and the increasing hydraulic power required

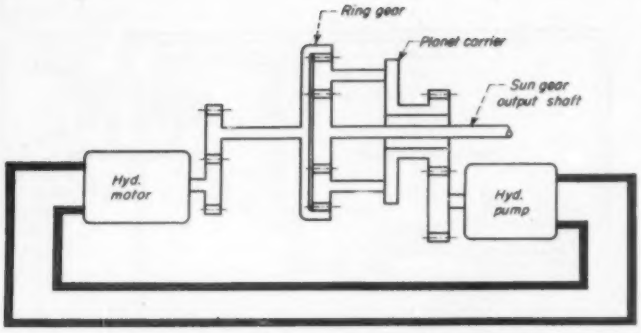



**Fig 18—Another type of differential transmission consisting of a hydraulic pump and motor and a planetary gear train.**

to provide a wide range of speed ratios.

As might be expected this differential transmission is but one of several versions. One other version utilizes the fundamental characteristics of the differential gear train in conjunction with a conventional reversing type hydraulic pump and motor transmission. In a differential gear train there are normally three members that are free to rotate, but only in a fixed relation to one another. In a planetary gear train, for example, the three members are the ring gear, the sun gear, and the planet carrier. If one of these members is used as the input member and another as the output, the relative speed of the two can be varied by selectively varying the speed of the third member. By coupling a variable displacement pump to the regulating member and a motor to either the input or output member, Fig. 18, a differential transmission is again achieved. When the members to which the pump and motor are coupled are locked hydraulically, unit speed ratio between input and output occurs. To provide varying speed ratios, it is only necessary to produce flow work, increasing or decreasing the relative speed of the regulating member. This principle of operation is substantially identical to that of the previously described differential transmission.

The greatest single advantage of the differential transmission is its higher overall efficiencies in comparison with the straight pump and motor transmission. The mechanical gear and bearing losses in a differential transmission can be made relatively slight; also, the slip loss in the hydraulic circuit at the straight-through drive condition are quite low. Since these represent the only appreciable losses, peak overall efficiencies in excess of 90 percent are feasible as compared with 80 to 85 percent with the straight pump and motor transmission. As the speed ratio and the amount of flow work increases, the efficiency of the differential transmission proportionately decreases and ultimately approximates that of the straight transmission. In Fig. 19 is shown a characteristic performance curve.

Another advantage of the differential transmission is that a comparatively small pump displacement is required to achieve a wide range of output shaft speeds. To maintain a constant horsepower output over a speed radio of four to one in a straight pump and motor transmission requires a pump displacement at least four times that of the motor. In a differential transmission for the same operating conditions, the basic pump displacement need be only twice that of the motor, taking advantage of the reversing displacement potential of the pump. While a reversing displacement pump is more complex than a pump that is variable in displacement in one direction only, the advantage frequently rests with the smaller displacement reversing pump in the differential transmission in terms of overall size, weight, and even ease of manufacturing.

Unfortunately the differential transmission is not nearly as flexible in application as the straight pump and motor transmission. Inherently it is restricted to a single direction of output rotation relative to input shaft rotation. Also, the differential transmission principle can be applied only in a close coupled assembly, while the straight pump and motor transmission can be either close coupled or remotely located for convenience in arrangement and conservation of space.

In the final analysis, the critical factors of each particular installation must be evaluated to determine what type of transmission best suits that installation. It is safe to say that the characteristics of both the differential and straight transmissions are sufficiently distinctive to insure the continued development and application of both types. It is a certainty that in the future, the use of these hydrostatic systems both for power transmission and control will be expanded.

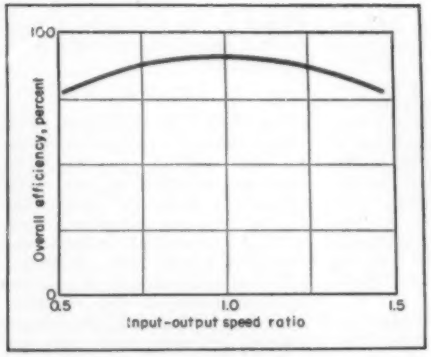



**Fig 19—Characteristic efficiency curve for the differential type of transmission. Best performance is obtained at a speed ratio of 1:1.**

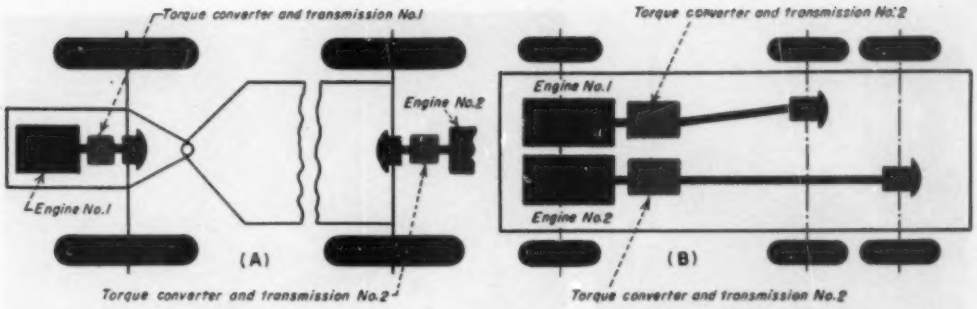



**Fig. 20—Two applications of hydrokinetic converters for balancing torque loads: (A) Euclid bottom dump wagon with two engines and two transmissions, including torque converters; and (B) Euclid tandem axle truck with an engine, three-speed geared transmission, and torque converter for each axle.**

# Hydrokinetic Transmissions

As previously discussed, a hydrokinetic transmission operates on a velocity change of the hydraulic fluid. The best known type—and actually the only one being extensively applied—is the hydraulic torque converter, which is an automatic, infinitely variable torque ratio transmission that, within a predetermined range of operation, adjusts the speed of the load to correspond to the resistance to moving the load; in other words, the hydraulic torque converter is a device that automatically increases the mechanical advantage of the driving motor when the load increases.

A mechanical transmission is also a torque converter because it multiplies the engine torque delivered to it according to the ratios of the gears in mesh at any one time. However, most transmissions are manually operated and the operator must select the gear ratios closest to the one required and shift gears accordingly. The choice of ratios is limited to a definite number depending upon the design; but the ratios in a hydraulic torque converter are infinite in number as they are automatically varied according to the sensitive demand of the loads without any guesswork or gear shifting on the part of the operator. Because of this, smaller motors or engines sometimes can be used, thus making possible better fuel economy than if a heavy engine, which subsequently would be operated at a light load factor, were used to start the load; also, two converters can be used to equalize the load on multiple engine drives, Fig 20, since each will automatically adjust the torque to fit the load requirements.

There are several other inherent advantages of the hydrokinetic transmission, some of which duplicate those of the hydrostatic type. Shock and overload protection is insured; large amounts of power can be transmitted with a relatively small converter; a stalled pull can be exerted on a driven mechanism; and since the power transmitted varies as the cube of the speed, the capacity of the converter can be changed merely by altering the input speed.

However, a word of caution is required regarding this latter point. Accurate data is required as to engine and load characteristics if maximum efficiency and performance are to be obtained. The power absorbing characteristics of the converter impeller will not permit the engine to operate in excess of the maximum speed for which the converter blading is designed. For this reason, it is imperative that the designated input speed corresponds to optimum engine horsepower after all deductions are made for accessory drives. If the engine horsepower is less than that for which the converter is bladed, the engine will never come up to speed and consequently will not deliver its maximum power. On the other hand, a small converter on an oversized engine will absorb only that amount of horsepower for which it is bladed; the engine will not deliver its full power at any given speed. It is essential, therefore, that the converter be carefully matched to the engine with which it will be used to secure maximum performance.

Another advantage of the hydrokinetic torque converter is that direction connection to the engine does not complicate starting inasmuch as the impeller absorbs negligible power at cranking speed. However, if the application requires any full cut-off between engine and load—as for example, when a reverse gear between the engine and converter must be shifted—then a cut-off clutch of some type must be interposed in the system.

## Limitations of the Hydrokinetic Torque Converter

Balancing this somewhat imposing list of advantages is a list of limitations—also imposing, in many cases:

1—In the smaller sizes—say below 300 hp—the hydrokinetic converter is more expensive than conventional transmissions, but usually is cheaper than such transmissions at higher hp ratings. (This comparison does not include adjustable speed electric motor drives, since the hydraulic unit is almost always cheaper and lighter.)

2—Losses in the fluid result in waste heat energy and greater

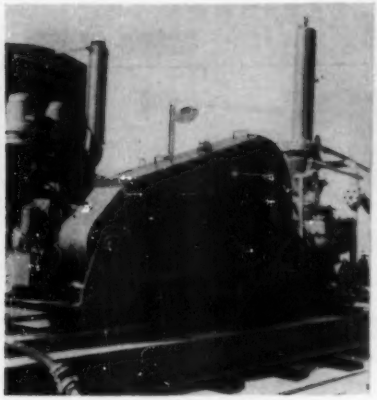


Fig. 21—Oil well equipment having a Twin Disc three stage converter drive. This represents one of the biggest industrial fields of applications for hydrokinetic fluid torque converters.

Fig. 22—Allis-Chalmers HD19 tractor equipped with a three stage hydraulic torque converter. Advantages gained, besides high torque multiplication, are an ability to exert a stall torque, rapid stepless acceleration, and cushioning of the drive against vibration and shock.

fuel consumption than if a mechanical drive were used, although in the case of diesel engines, this does not always apply. Since heat is generated, it must be dissipated, and while blowers or forced air circulation over the converter is practical with small sized units, a cooling radiator or water-cooled heat exchanger is almost mandatory in larger units.

3—A hydrokinetic converter is inherently a single directional device. If load reversal is necessary, a reverse gear train and disconnecting clutch must be added behind the converter in place of the more simple reversal valves associated with the hydrostatic type.

4—On some applications an engine governor, controlled by the torque converter output shaft speed, is required. The most pertinent example is power shovel and drag line operation where the variable torque ratio is desirable during the digging part of the cycle, but the high speed resulting from the light load in the swing part of the cycle is objectionable. The output shaft governor lets the engine operate at full speed during the digging operation and at reduced speed and part throttle during the swing operation.

When all is said and done, the basic advantages of the hydraulic torque converter are its ability to do more work with a given amount of horsepower, its high horsepower transmitting capacity, simplicity of operation, inability to transmit shocks or torsional vibrations, and also the fact that variable torque transmissions of similar characteristics either are not available or are more costly.

As previously indicated in Table I, hydrokinetic transmissions of the torque converter type are being applied on an increasing scale for combustion engine drives. A number of applications have been made in logging equipment, in industrial and switching locomotives, passenger cars, tractors, and oil well equipment, Figs. 21 and 22. The use of hydraulic torque converters in diesel engine and gasoline engine driven busses is already widespread, and will probably increase further, especially in diesel engine installations because of the fact that it is essentially a constant speed motor. Motor truck installations have been made, but not so extensively as with other vehicles.

In the industrial field, earth moving, logging, hoisting, and oil field apparatus is being equipped with torque converters, and it is entirely possible that many pieces of equipment now utilizing fluid couplings may in the future be replaced by hydrokinetic torque converters. In short, the application possibilities, particularly in the industrial field, are just beginning to be realized.

# Basic Types of Torque Converters and Couplings

The various types of torque converters vary widely as to their design. The only points of similarity are that roughly they have a torus or doughnut circuit shape, have multiple blade stages, and use a petroleum product as their power transmitting medium.

Actually, the working of a torque converter can best be described by starting with a fluid coupling, which is not a transmission at all; it is a one to one torque ratio device and therefore is a type of clutch. It can be built with very little theory and, since slip is a function of size, is simply made bigger if the operating efficiency is poor. The

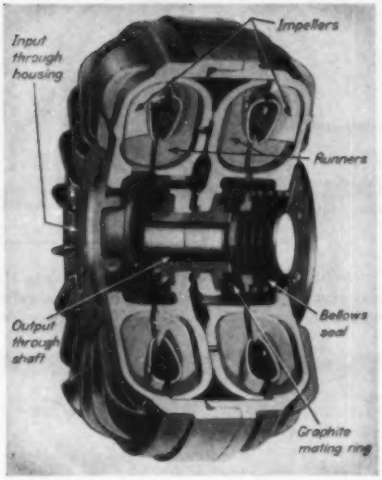



**Fig. 23 — Two element hydraulic coupling. Power input is through the housing and power output through the shaft. Torque ratio is 1:1 at any speed rate.**

unit cost is low, and the tooling to make it need not be as extensive as for a fluid torque converter.

## Hydraulic Coupling

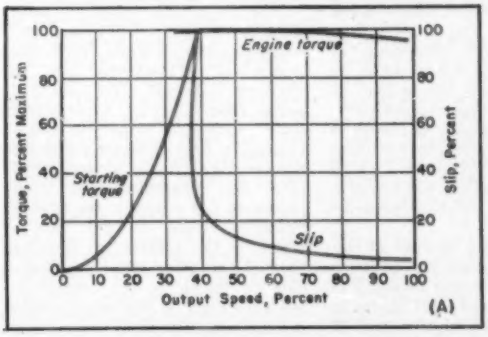
A hydraulic coupling has a torus shaped split housing in which blades or vanes are set radially to the drive shaft, Fig. 23. The drive half of the coupling is called the impeller, and the driven member, the runner. The vanes in both the input and output members separate the oil into distinct paths and prevent eddying when the unit is in operation.

As the impeller starts to rotate, the oil is thrown toward the outer rim of the housing and becomes a moving fluid mass. When this mass strikes the stationary blades of the runner, it exerts a force on them proportional to the weight of the fluid that is pumped out of the impeller every second. This kinetic energy is recovered in the runner by retarding the forward rotation of the oil mass, which then flows back into the impeller and again picks up momentum. Since the blades of the coupling are straight and on radial lines, making the coupling entirely reversible, it will transmit torque in either direction with the same efficiency; either member may be used as the impeller.

What actually happens as an engine is started and the coupling comes up to speed is illustrated in Fig. 24. In the starting zone, the coupling connected to a load at rest offers negligible resistance to free turning of the engine and hence facilitates engine starting without a cut-off clutch. Under stall conditions of the coupling output shaft, the engine may be operating at a speed as high as 40 percent of the governed speed or higher, depending on the type and design of the coupling. As sufficient torque is developed to move the load, slip diminished rapidly. The result, considering the engine and coupling as a unit with performance measured at the output shaft, is shown at (B). Full engine torque is available at all output speeds from zero to 100 percent. Output torque is always equal to input torque—there being no torque multiplication—and maximum torque is delivered even if the load is at a complete standstill.

With electric motors, the operating characteristics of a coupling are somewhat different. Hydraulic couplings permit an electric motor to accelerate rapidly out of the low speed region of operation in which high current is drawn. Hence the amount of special motor starting equipment is reduced. If the coupling is properly selected, the motor speed will rise rapidly to a point near maximum torque conditions. Following this, the speed of the load will increase rapidly until it approaches motor speed, and the slip decreases to a minimum.

With the output shaft at rest, the



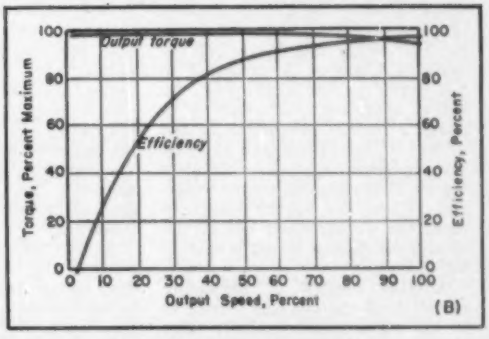




**Fig. 24—Fluid coupling performance with a diesel engine drive: (A) on starting, output torque increases rapidly, and slip decreases; (B) in operation, efficiency increases with decreasing slip to a maximum of 96 to 97 percent for a well-designed coupling.**

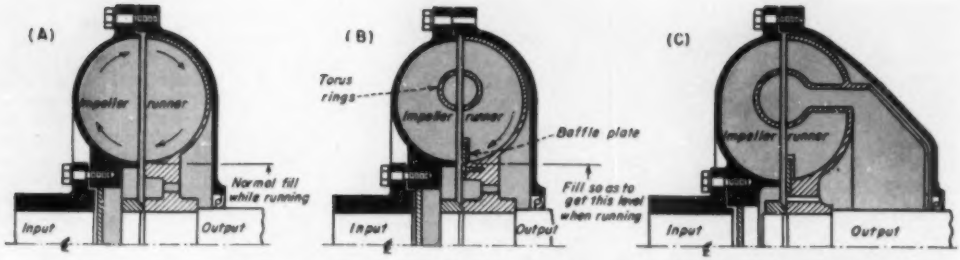



**Fig. 25—Standard and modified coupling circuits: (A) conventional traction coupling, 100 percent fill; (B) modified coupling with torus rings and baffle plate; (C) traction coupling with deaerating chamber; (D) traction coupling with eccentric runner; (E) traction coupling**

coupling resists so slightly that the motor promptly reaches maximum torque speed. At this point, the slip drops as the load begins to move. Nearly maximum torque is available to start the load from zero speed, yet the starting current instantly falls to reasonable limits, obviating the need for starting devices.

The curves Fig. 24 are for a coupling that has been modified from the theoretical design to obtain characteristics that better match motor performance and load characteristics. The normal traction coupling (*A*) Fig. 25 has a true torus shaped circuit with straight radial blades; a similar unit is used by Hot Point in a washing machine drive. To secure better control of the circulating fluid, core rings or torus rings may be added to one or both members, (*B*). The baffle plate shown in this illustration is used by American Blower, and is effective in reducing drag torque, although at some sacrifice in torque capacity.

A third modification (*C*), also made by American Blower, consists of a deaerating chamber in the runner half of the coupling. This deaerating chamber is connected to the center of the torus ring. In actual operation, the effect is to dump a certain percentage of the oil out of the circuit and to draw the displaced air into the circulating oil, thus reducing torque capacity. When the runner starts to turn, the air separates out of the oil and the oil returns to the operating circuit.

Another method of displacing the oil from the working circuit is to use an eccentric runner, (*D*). Under stall conditions, the eccentric runner directs the fluid toward the hub, thus impeding the rate of circulation and reducing drag torque. This design was developed by Borg-Warner, but was never put in production. A third method of producing the same general effect is shown at (*E*), where an opening is left in the inner part of the circuit; this is a Twin Disc design used on large size couplings.

Finally, since the torque capacity of any pump is a function of the mean radius, $R_i$, at which the pump receives its fluid and the mean radius, $R_o$, at which the pump exhausts its fluid by increasing the size of the torus or core ring the inner radius, $R_i$, is reduced and the outer radius, $R_o$, is increased, thus increasing the effective capacity of the pump, (*F*). However, at the same time, this reduces the total area and increases the friction loss of the circulating fluid. As the rate of circulation is many times greater at stall than under normal running conditions, a satisfactory reduction in drag torque is secured. This coupling is the standard Twin Disc model.

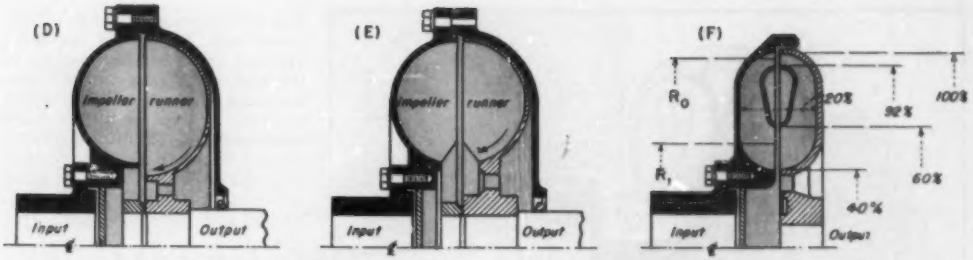
Under full power stall conditions an hydraulic coupling emits a low level noise which may be objectionable, particularly in passenger car applications. This noise may be reduced considerably by using an even number of blades in one member and an odd number of blades in the opposite member or by using the same number of blades in both members but with non-uniform spacing to break up the harmonic vibration.

Another effective method of improving the relationship between drag torque and torque capacity is to increase the number of blades in the circuit. Still another method of reducing drag torque with the runner stalled is to dump part of the oil out of the circuit into an external reservoir either by automatic or manual means.

This brings up the point of the two basic types of fluid couplings (not modifications) that are being made: The traction type and the disconnecting type. The traction coupling is filled with oil up to about 80 to 90 percent of capacity, space in the hub being allowed for expansion of the oil due to heating. This type is usually a sealed unit, and is cooled by fins on the outside of the housing.

The disconnecting type of coupling, on the other hand, is so designed that it can be filled and drained, and thus combines the advantages of a clutch and hydraulic coupling in one unit. While there are several methods of removing the oil (a scoup tube, as used by American Blower or a quick dump valve as used by Twin Disc) in essence the external circuits are quite similar. There must be a fluid pump, driven by the prime mover or a separate drive motor, and there usually is an external heat exchanger.

One Twin Disc hydraulic power take-off consists of a twin circuit coupling having a chain driven gear pump and an external heat exchanger. Output from the gear pump flows through a three way valve, where it either is passed through a heat exchanger and into the coupling, or else is passed back into the reservoir. The dump valves on the coupling are opposed pressure valves, on one side of which is the centrifugal pressure from the coupling and on the other side of which is the centrifugal pressure head of the balance tube. A small quantity of oil is constantly bled from the balance tube side of the pressure-balanced valve through the control orifice in the




**with incomplete internal circuit; (F) traction coupling with torus rings and modified housing for flow restriction. Couplings are modified to improve their performance characteristics—or specifically, to improve the relationship between drag torque and torque capacity.**

valve. To drain the coupling, the oil supply is cut off by turning the three way valve. Sufficient oil quickly escapes from the balance tube through the control orifice to permit the pressure in the coupling to open the dump valves. The working fluid then, under the influence of centrifugal force, is ejected at a rapid rate through the large ports uncovered by the dump valve piston. To engage the coupling, the rotary valve is turned to direct the flow from the pump through the heat exchanger, into the inlet passage in the front space around the input shaft, and out the angular passages to the coupling circuit. The first oil through the angular passages flows out the balance tubes and closes the dump valves so that the coupling will fill.

While the hydraulic coupling by itself is not a transmission, as previously stated, it can be connected through a planetary gear train Fig. 26 to provide a substantially constant power output with wide variations in output shaft speed. In this drive, the ring gear of the planet set is attached to the coupling housing with the planet pinions attached to the shaft that carries the coupling runner. The sun gear drives the output shaft. This is a regenerative type of gear system in which the input and output torque must be equal but the runner torque is 3.25 greater than either input or output torque.

Assuming that the coupling is at rest with the output shaft held stationary, the drive functions in the following way: Rotation of the coupling housing impeller causes circulation within the coupling circuit and also causes the ring gear to rotate. Since the output shaft, and therefore the sun gear, is stationary, the planet pinions rotate the runner in the forward direction at a decreased speed, the exact ratio depending on the ratio of the planetary gear train. In other words, the maximum slip rate between the coupling impeller and runner is governed by the gear ratio—being 30 percent in this instance—and it is possible to select a ratio with a maximum slip rate that will permit operation at or near stall conditions for an extended period of time.

If a partial load is imposed on the output shaft, the slip rate between the impeller and the runner increases until sufficient torque is available to handle the load. Advantage is taken of the pull-down torque increase of an engine or motor to maintain a more or less constant horsepower output over a wide range—but not the full range —of output speeds.

Drives of this type have been applied successfully to textile or wire winding machines. However, they have inherently a low-power transmitting capacity.

## Single Stage Converter

The hydrokinetic torque converter differs from the fluid coupling in many respects, the most significant of which is the addition of a stage consisting of guide vanes. This guide stage in effect, adds the fulcrum to the lever between the driving and driven members that allows the torque to be multiplied. An elementary torque converter thus consists of a pump, a reaction member or guide stage, and a hydraulic turbine.

In visualizing the operation of a fluid torque converter, it is important to remember that the fluid flows essentially in two directions: Around the converter in the same direction of rotation as the converter and the shaft; and around the torus shaped ring formed by the various stages. (See the three stage converter, Fig. 28.) It is the flow around the shaft that the guide stage must reverse so that the fluid enters the following stage in the proper direction of rotation.

The blading in the converter is similar to that in a steam turbine except that (1) instead of being in a straight line from entrance to exit, it is in a circular path around the housing; and (2) it is always reaction type blading. The pump imparts to the fluid a certain kinetic energy that is removed in the turbine. When the output shaft is at rest, the energy is converted into heat but the torque factor is high. As the driven shaft comes up to the speed of the pump, the efficiency increases rapidly and the torque multiplication drops, the reason being that the angle at which the fluid strikes the reaction member becomes less and the thrust that it exerts therefore also becomes less.

This single stage converter can be operated from zero to racing speed—i.e. to maximum speed of the driving motor. However, when the converter reaches racing speed, the exact value of which depends on the design of the converter, the fluid from the guide stage starts to hit on the back of the turbine blades, one effect of which is to cause excessive losses. At this point, the guide stage usually is free-wheeled, the torque ratio between input and output becomes 1:1, and the converter becomes a fluid coupling.

The effect of this on the efficiency curve for any given converter is that when the fluid starts to hit the back of the turbine blades the

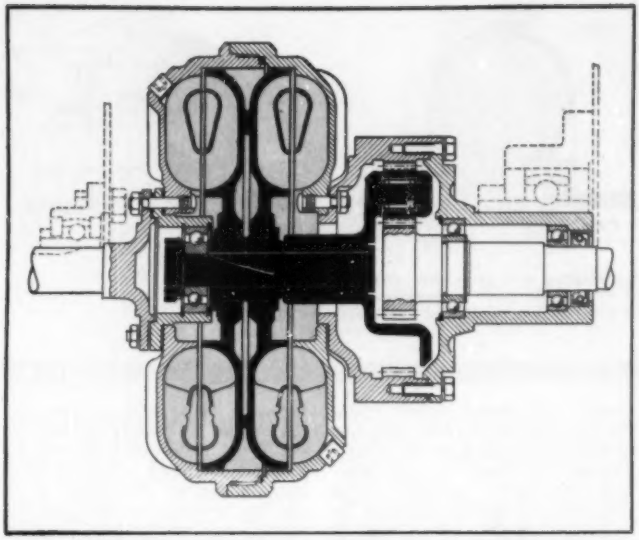


**Fig. 26—Twin Disc Hydrowynd drive for a winding machine with a two element hydraulic coupling and simple planetary gear train. This is a differential transmission somewhat similar in operation to differential hydrostatic transmissions and produces relatively constant output horsepower.**

efficiency drops off; except when the guide stage is free-wheeled, the efficiency has a direct relation to speed ratio or slip, as the converter has become a fluid coupling. The speed ratio at which the maximum efficiency occurs is normally considerably less than the speed ratio at which the clutch point of 1:1 torque ratio occurs. Therefore there is a dip in the efficiency curve. To alleviate this condition, the reaction stage may be split into two parts, so that one part can be free wheeled when the fluid first starts to hit the back of the guide blades, and second part can be free wheeled when the condition again becomes critical. A converter of this type is known as a single stage, polyphase converter. The effect of polyphase perfor mance on the operation is to minimize shock losses and give a constantly rising efficiency curve.

Polyphase construction is not necessarily limited to the reaction stage. The pump also can be split into parts, to help the flow from the turbine into the pump and reduce shock losses. Another advantage that often can be gained by splitting the pump is a constantly rising engine speed, which is difficult to obtain in a single stage, single phase converter. Engine speed usually is higher at a zero shaft output speed and maximum torque multiplication than at a point where the input-output speed ratio is higher; this, plus a maximum torque multiplication of about 3 to 1 is the basic disadvantage of a single stage unit.

There are at this writing six different single stage converters in production, and another is ready to go. These are: (1) a Schneider three element converter, available in capacities ranging from 5 to 5,000 hp, which is being made by the Schneider Manufacturing Corporation, and under license, by the White Motor Company and the Torcon Corporation; (2) the "Dynaflow" being manufactured by the Buick Division of General Motors; (3) the "Powerglide", made by the Chevrolet Division of GM; (4) a four element polyphase converter manufactured by the Allison Division of General Motors; and (5) a single phase converter being made by Borg-Warner for the Studebaker Corporation. Another single stage converter is being made by Borg-Warner for the Ford Motor Company. Characteristics of these units are as follows:

**The Schneider three element converter,** chart following page 136 develops more than three times engine torque with the output shaft stalled. The housing rotates at engine speed, and as the reaction member is mounted on a free-wheel unit, the torque converter becomes an hydraulic coupling in the high speed range. The curve indicates the performance characteristics with engine speed expressed as percent of maximum speed. This unit has a somewhat higher engine speed at the stall end of the curve than through the normal working range.

**The Buick Dynaflow,** is a five element single stage polyphase converter also having a rotating housing In order to develop a unit suitable for automobile drive the guide stage has been split into two parts and the pump has its more sharply curved portion at the inlet split off and free-wheeled. The two guide stages are free-wheeled from a stationary member whereas the secondary pump is free-wheeled from the main pump wheel. This converter likewise has a rotating pump housing and becomes an hydraulic coupling at high speeds. By this means, a continuously rising engine speed curve and continuously rising efficiency curve is obtained. Due to the high power to weight ratio of a modern automobile, high torque ratios are not required in the torque converter.

**The Allison converter,** is a modification of the Buick type with the omission of the secondary pump. Stall torque ratios of about 4 to 1 are secured and the engine speed curve shows the same characteristics as the Schneider unit in that the engine speed with the output shaft stalled is higher than in the normal working range.

**The Studebaker unit** is a single stage unit with a lock-up clutch that is engaged to give full mechanical transmission at high speed level. The operating curves indicate a torque ratio of 2.15 with an efficiency of 90 percent. Since this transmission normally starts in second gear as compared with high gear or direct as in the case of Buick and Packard, the flatter curve apears more desirable. When going from second into direct, the direct-drive clutch gives positive drive and the torque converter idles, transmitting no load. Kick-down from high into second may be had at any speeds up to approximately 55 mph. Since a lock-up clutch is used, maximum efficiency is not of extreme importance. For example, when

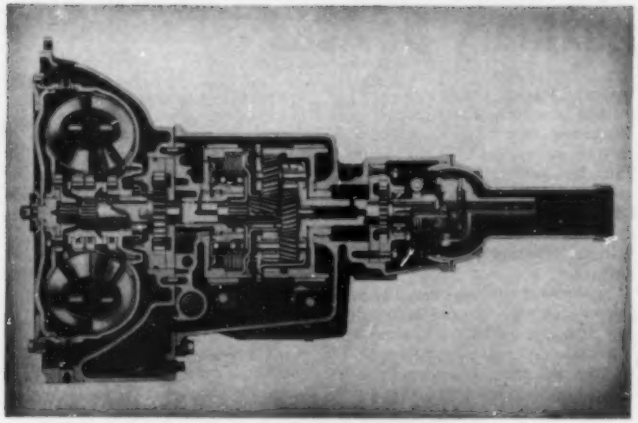


Fig. 27 (Above)—Cut-away view of the new Chevrolet "Powerglide" transmission. The converter is a single stage, polyphase unit, with blading inside the torus ring.

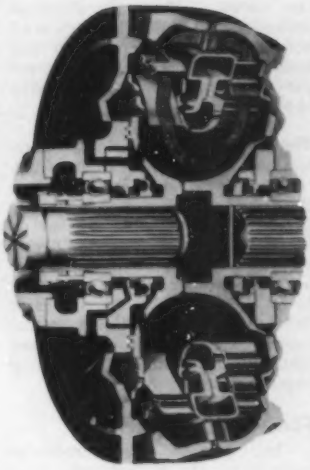


Fig. 28 (Right)—Construction details of a three-stage converter. Oil flows through the converter in the same and opposite directions as shaft rotation, and also around the housing, as indicated by the arrows.

climbing a long grade or towing a trailer, the transmission will either be in direct or will be in second. In second gear, the gear ratio allows the engine speed to "rev up" sufficiently so that the converter is operating as a coupling where the efficiency is adequate for the most extreme conditions. Direct air cooling has been found entirely satisfactory for all conditions of driving, so plumbing or inter connections with the car's cooling system is unnecessary. Air is drawn into the bell housing at its rear, forced between the shroud portion of the fan assembly and the outer surface of the impeller housing and out through openings at the larger diameter of the bell housing.

**The Chevrolet converter** is essentially the same design as the Buick unit except that the blading and other major components are stamped, rather than cast, and blades have been added inside the torus ring, Fig. 27. The torus ring thus acts as a fluid coupling, with the result that better downhill to engine braking is obtained and the car can be started by pushing it.

**The Ford converter,** which was developed and is to be manufactured by Borg-Warner, is a single stage converter of the non lock-up type that is followed by an automatic three-speed, mechanical transmission.

Only general details of this drive have been released for publication, and no converter performance curves are available.

There is another single stage torque converter just entering production. It is a Schneider unit, licensed to the Fuller Manufacturing Company, who are building it for the Ford Motor Company for door to door delivery trucks. No information was published on this unit when this article went to press but it is in production and complete details should be available in the relatively near future.

## Two-Stage Converters

The two stage converter differs from the single stage unit by another turbine stage; that is, it has a pump, reaction member, and two turbines. Advantages of this type are that it need not be any more complex than a single stage polyphase unit; it has uniformly rising engine speed characteristics so that, when used with an internal combustion engine, the operator does not get the sensation that the engine is racing at stall conditions; and it has inherently higher torque multiplication, on the order of 4 to 1.

Instead of a free-wheeling guide stage, a two stage converter usually is used with a lock-up clutch that is made a part of the transmission. In short, the converter is taken out of the drive circuit when the clutch point or 1.0 to 1.0 torque ratio point is reached.

There are two two-stage converters in production and one about ready to be manufactured: (1) the General Motors Truck and Coach V Drive; (2) the Packard "Ultramatic"; and a recently announced Twin Disc unit. Characteristics are as follows:

**The GM Truck and Coach converter,** see chart, is in use on buses at the present time. This is a stationary housing type converter with a fixed reaction member, and employs direct drive for the high speed operation, with clutches and free-wheels so arranged that the hydraulic converter does not rotate when the direct drive clutch is engaged. Also, the drive does not pass through this unit as in all other converters, both the input and output shafts being on the same side. The stall torque ratio is over 4 to 1, and the engine speed curve continuously rises with an increasing speed ratio.

**The Packard "Ultramatic"** has a housing that rotates at engine speed and a free-wheeled reaction

member. A direct drive clutch is engaged for high speed operation, and one single reaction member is free-wheeled to eliminate hydraulic losses near the high speed end of the curve. This unit develops around 2.4 engine torque at stall and shows the rather steeply and continuously rising engine speed curve as required for automotive application.

**The Twin Disc** two-stage industrial converter has the turbine carried by the housing, and therefore the housing rotates at output shaft speed. The reaction member is free-wheeled and a direct drive clutch may be incorporated for high speed operation to eliminate hydraulic losses. This converter develops around 4 times engine torque at stall conditions and maintains a continuously rising engine speed curve.

### Three-Stage Converters

The original Lysholm-Smith patents on the hydrokinetic converter involved a three stage unit, and consequently it was the first type to be placed in production in this country. Since six rows of blading are required—a pump, two reaction stages, and three turbine stages—it is necessarily more complex and expensive to build. It develops higher torque ratios than any of the other types.

The reaction members on this type are fixed at all times, and the converter may or may not be shunted out of the drive by a lock-up clutch at high speeds, depending on the application.

Only two commercial three-stage models are being manufactured, one by Twin Disc and another by the Spicer Division of Dana Corporation. The Twin Disc unit has been primarily an industrial converter, while that made by Spicer has been used for motor vehicles, particularly buses.

**The Twin Disc** unit, Fig. 28, produces about five times engine torque with the output shaft stalled and is bladed so as to maintain the engine at near maximum governed speed through the working range.

**The Spicer** torque converter as developed for automotive service has about six times engine torque at stall and has a steeply rising engine speed characteristic typical to automotive-type drives. A direct drive clutch is used at high speed.

# Auxiliary Devices

Certain auxiliary devices are required to obtain satisfactory performance from any hydrokinetic torque converter. These devices can be broken down into two classes, that is, those that are necessary for converter operation and those that are required to obtain satisfactory transmission performance.

In the first category are a charging or auxiliary pump, a circulating pump, a cooling radiator, and a pressure regulating valve. As a matter of fact, the conventional hydrokinetic converter circuit is not unlike that of the disconnecting fluid coupling. The charging pump keeps the converter supplied with oil and maintains pressure on it to prevent cavitation. A single stage unit also requires a circulating pump which may be combined with the charging pump to circulate oil through the cooler. Three-stage and most two-stage types rely on a natural pressure difference between the converter and the cooler for circulation, although a two-stage unit is rather tricky and some require an auxiliary circulating pump.

The cooling radiator, of course, is necessary to cool the oil. A considerable amount of heat is generated in any hydrokinetic fluid device and the torque converter is no exception. Only one automotive model is known that does not have a radiator or cooler; it will rely on forced air circulation over the converter housing to cool the fluid. However, most big units have a separator radiator.

In the category of auxiliaries necessary to secure satisfactory transmission performance is such equipment as disconnecting clutches, reverse gear drives, lock-up drives, stepped (geared) transmissions, and output governors.

The hydrokinetic torque converter is not a clutch. To get neutral, a master clutch or power shift transmission with clutches or bands for individual transmission speeds is required. If reversal is necessary, a reverse gear train must be placed in back of the converter, since as previously mentioned, the blading is so designed that the converter itself is non-reversible. The necessity for an output shaft governor (or a direct drive clutch) in those applications requiring nearly constant speed operation has previously been covered, as has also the function of a lock-up clutch.

The goal of the converter design engineer normally is to match the engine and torque converter performance so that the engine is pulled down to its peak torque speed at stall for three reasons. First, output torque is the product of engine torque and stall torque ratio; therefore, by pulling the engine down to its peak torque at stall, more output is available for a given stall torque ratio. Second, at stall speeds, the efficiency is zero; therefore, the lower the engine speed the less the fuel consumption. Third, it follows that the heat generation will be less.

But why use a forward gear train in back of the converter when it is popularly supposed that one of the primary advantages of such a device is to do away with the need for shifting gears? The answer is this: In many applications, high speed requirements are such that the converter must operate beyond its most efficient range. If a direct drive clutch or combination hydraulic coupling and torque converter do not give the required characteristics, the best compromise usually is a two or three speed stepped transmission. Such a transmission shifts the shaft speed so that the converter again operates at the most efficient input-output speed ratio.

The type and construction of such auxiliary transmissions vary as widely in design as the different makes of converters. Some, particularly on automotive vehicles, are planetary; some are automatic in operation, depending on mechanical or hydraulic flyball governors to shift speeds in a predetermined sequence. However, such devices are a subject in themselves, and actually require individual analysis and design for each application.

Where do we go from here in the application of these hydrokinetic converters? Certainly the automotive use will be expanded, but this is a very specialized application. It is in the industrial field that perhaps the greatest potential lies; for any machine or device that must operate against a variable load, the torque converter appears to be a promising and probable transmission choice.

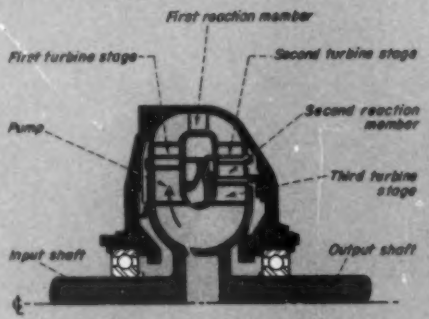
# Hydraulic Torque Converters Now in Production

Ten models of hydraulic torque converters, some of which are available in capacities from 75 to 5,000 hp, are now being made in the U.S. for automotive or industrial use. In addition, several other concerns either have units under development or are manufacturing one of the present types under license. The Schneider single-stage converter, for example, is also made by the White Motor Company and The Torcon Corporation.

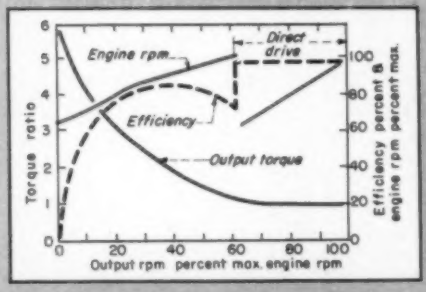
The basic construction and operating characteristics of eight of these ten types are shown in this chart. These models range from single stage types made by Schneider, Borg-Warner (for Studebaker), Buick, and Allison to two and three stage units manufactured by Twin Disc, Spicer, Packard, and GM Truck and Coach. Not included is the new single stage converter to be made by Borg-Warner for Ford, or the single stage Chevrolet converter, which is quite similar in construction to the Buick "Dynaflow."

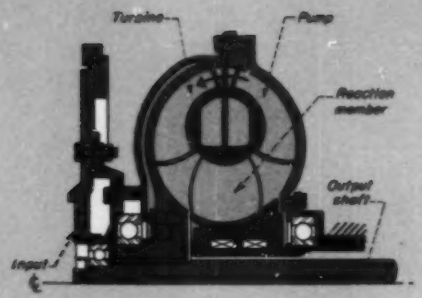
Of these four single stage converters, all have rotating housings and free-wheeled reaction members; the Buick converter has five elements, the Allison four, and the others three. Of the two stage units, both Packard and Twin Disc have rotating housings and free-wheeled reaction members, while GM Coach has a fixed reaction member and stationary housing. Both three stage types have fixed housings and fixed reaction members.

In the sketches, dark red indicates power output; green, power input; black, stationary or guide members; and light red, hydraulic fluid.

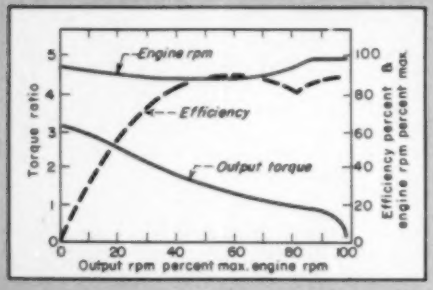


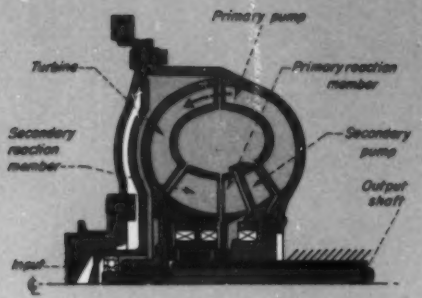

SPICER – THREE STAGE



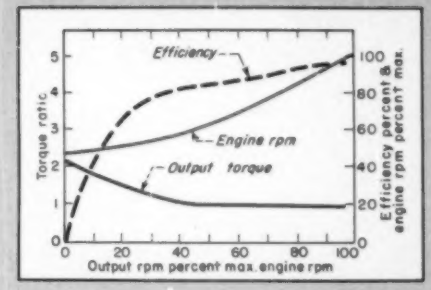


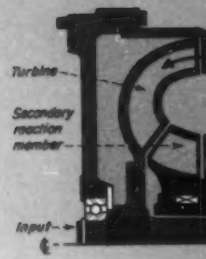

SCHNEIDER-SINGLE STAGE



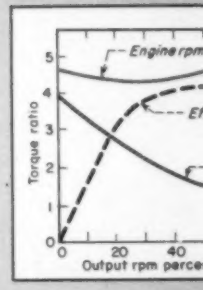



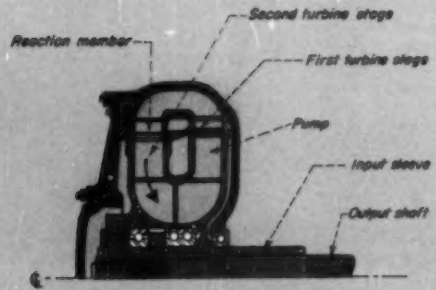

BUICK - SINGLE STAGE



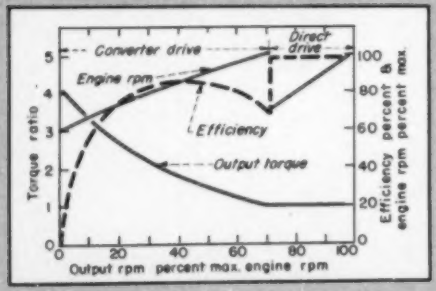



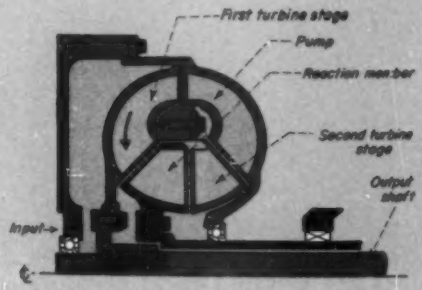

ALLISON-S



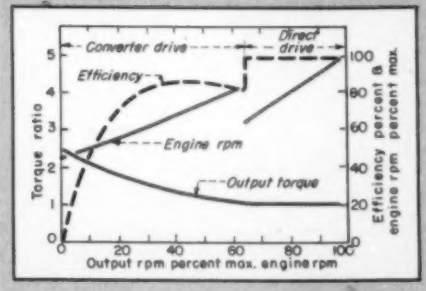



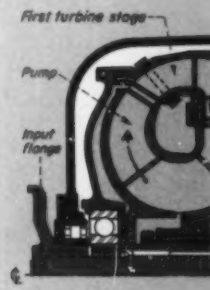

GM COACH - TWO STAGE



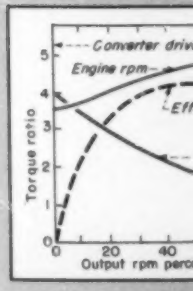



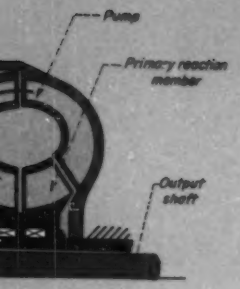

PACKARD - TWO STAGE



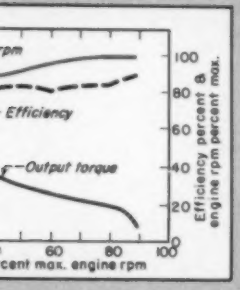



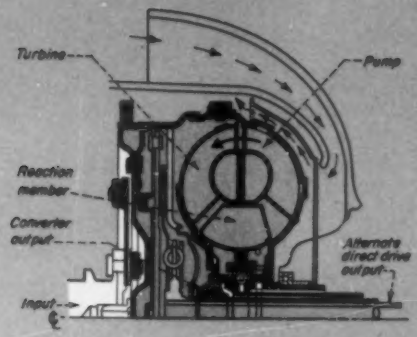

TWIN DISC



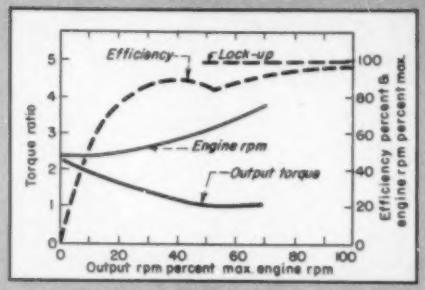



- SINGLE STAGE




STUDEBAKER - SINGLE STAGE



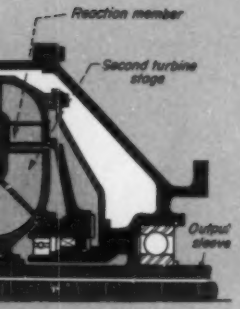

## Hydraulic Torque Converters Now in Production

Ten models of hydraulic torque converters, some of which are available in capacities from 75 to 5,000 hp, are now being made in the U.S. for automotive or industrial use. In addition, several other concerns either have units under development or are manufacturing one of the present types under license. The Schneider single-stage converter, for example, is also made by the White Motor Company and The Terzon Corporation.

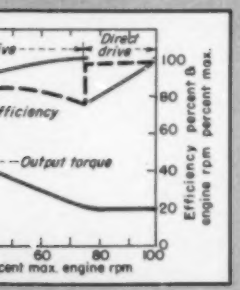
The basic construction and operating characteristics of eight of these ten types are shown in this chart. These models range from single stage types made by Schneider, Borg-Warner (for Studebaker), Buick, and Allison to two and three stage units manufactured by Twin Disc, Spicer, Packard, and GM Truck and Coach. Not included is the new single stage converter to be made by Borg-Warner for Ford, or the single stage Chevrolet converter, which is quite similar in construction to the Buick "Dynaflow."

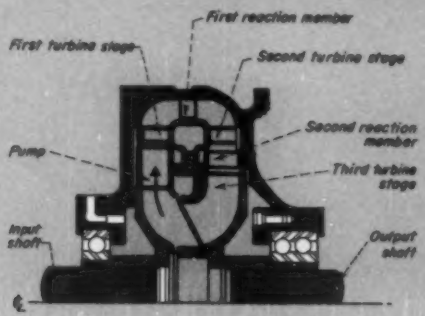
Of these four single stage converters, all have rotating housings and free-wheeled reaction members; the Buick converter has five elements, the Allison four, and the others three. Of the two stage units, both Packard and Twin Disc have rotating housings and free-wheeled reaction members, while GM Coach has a fixed reaction member and stationary housing. Both three stage types have fixed housings and fixed reaction members.

In the sketches, dark red indicates power output; green, power input; black, stationary or guide members; and light red, hydraulic fluid.

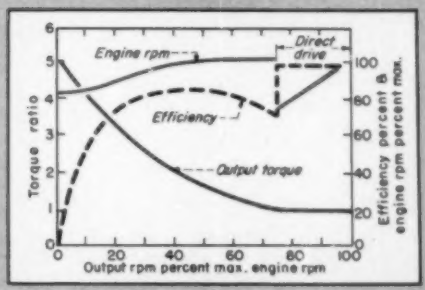


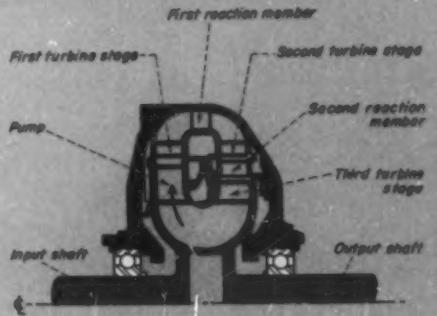

- TWO STAGE



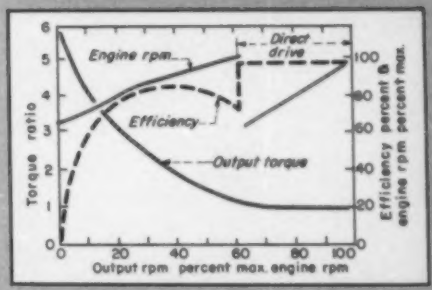



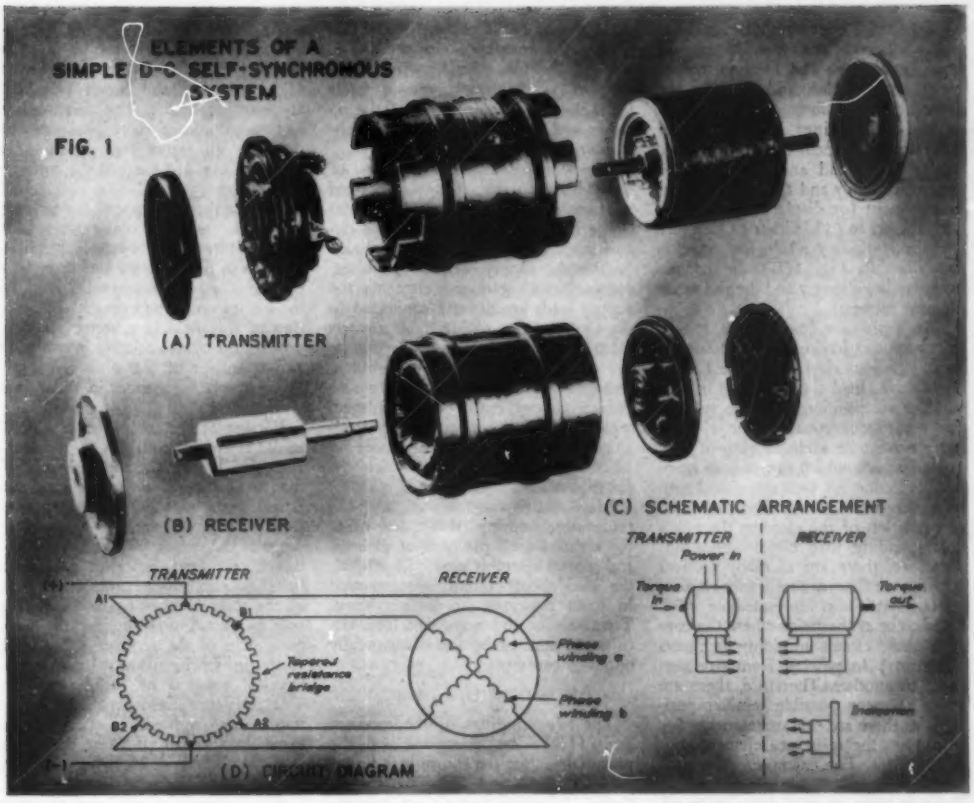

TWIN DISC - THREE STAGE




SPICER - THREE STAGE






**Yielding relatively simple solutions to many control problems that are difficult, or impossible, with a-c synchro systems, the new d-c positioners also compete in performance and cost.**

# How D-C Synchros Work

ROBERT A. GERG
Application Engineer
CHARLES R. MIKOLIC
Development Engineer
Control Section
Allis-Chalmers Manufacturing Company

THE ELEMENTS of the simplest synchro system, either d-c or a-c, are an electrical power source, an actuating (master) device to transmit signals by electrical impulses, a receiving (slave) device, that responds to these impulses and conductors connecting the two units in an electrical circuit. The actuating device is commonly called a transmitter, and the slave unit, a receiver. Exploded views of a typical receiver and transmitter, Fig. 1 (A) and (B) show the construction.

Unlike a-c synchros, the d-c transmitter and receiver are entirely dissimilar in design, construction and electrical operation. Fig. 1 (C) and (D) shows the basic elements and the electrical diagram of a d-c sinusoidal system, the type described in this article.

The d-c receiver stator construction is similar to a small motor except that special windings and magnetic iron are used. The winding is a two pole, two phase, concentric type in which the number of turns in each coil depends upon its location in the stator, and is determined, mathematically, according to a sinusoidal law.

The two pole receiver rotor may be any one of four types: (a) permanent magnet, (b) iron slug, (c) energized fixed field, or (d) wound armature having two or more independent windings. The permanent magnet type is commonly used in general applications. The others normally are used only to

obtain special operating characteristics or for reasons of economy. Instrument type bearings in the receiver reduce mechanical friction and increase the sensitivity of the instrument.

A d-c transmitter is composed of three basic elements, (1) resistance bridge, (2) load and supply circuit contact assembly and (3) a mechanical arrangement for displacement of (2) with respect to (1). Either (1) or (2) may be stationary while the other is movable. In Fig. 1(B) the contact assembly is stationary and the resistance element rotates.

The resistance bridge is a special potentiometer having a contact surface for continuous electrical connection to the receiver load circuits, in an infinite number of positions. To be suitable for continuous rotation, the element surface must be a closed ring of contact segments, which can vary in number up to one for each individual turn of a wire-wound unit. For each contact position of the element there is a corresponding load circuit condition; therefore, there are as many receiver positions as there are resistance element contact positions. Intermediate positions occur at the point where the contacts short circuit adjoining segments (or turns) in passing from one segment to another. Therefore, there are twice as many possible receiver positions as there are contact segments (or turns) on the resistance element contact surface. For example, a receiver connected to a transmitter element having two turns of wire (two contacts) per degree of surface, will be electrically sensitive to ½ of one degree change in mechanical position of the element with respect to its contacts. For this reason, the resistance element design and construction, whether wire-wound unit or a segmented type, depends upon the load requirements of the receiver and the desired number of control or indicator positions.

The contact assembly consists of individual contacts, mounted in fixed relationship to each other. It includes the terminals of the recciver load circuits and, in some units, the terminals of the d-c supply source. In transmitters having stationary elements, the supply leads are directly connected to the element, eliminating those contacts from the assembly. Rolling contacts are used on wire-wound elements to reduce friction and wear. They also reduce contact area to a minimum which gives best operating characteristics. Sliding contacts are used in units having larger contact segments for higher load capacities.

Mechanical construction of the transmitter housing, shaft, and other parts varies with the type of element and contact assembly used. In general, the load circuit contacts are mounted in fixed positions 90 degrees apart. Terminals of the respective load circuits are formed by the diametrically opposite contacts.

### Electrical Operation

The two windings of the receiver, Fig. 1(D), are energized by the potentials across the transmitter terminals TA1-TA2 and TB1-TB2, respectively. These potentials are complimentary sinusoidal functions of the mechanical angle of rotation of the transmitter from a given reference point of the system. The usual reference point is taken at the position in which circuit TA1-TA2 is at maximum (line) potential and circuit TB1-TB2 at zero potential. The relationship and magnitude of these phase potentials for all transmitter positions is shown in Fig. 2, a chart of the emf for each phase.

Because the resistance of the receiver windings remains constant, these potentials produce sinusoidal phase currents in the receiver, which create a resultant two pole magnetic field in the stator iron. The strength and position of this field is a vector quantity determined by the relative magnitudes and polarities of the phase currents. Fig. 3 shows the manner in which this vector varies.

Because of the complimentary sinusoidal phase relationships of both current and potential, the strength of the magnetic fields, as well as the power input to the receiver, remains constant throughout the operating range of the system. The relative position of the field, however, remains a linear function of the angular position of the transmitter. Therefore, a two pole receiver rotor, aligned in the magnetic field of the receiver stator, will rotate in synchronism with any mechanical rotation of the transmitter. The resistance element of the transmitter is wound with a special taper to produce sinusoidal phase potentials for the specified electrical loading corresponding to transmitter capacity.

Displacement of the receiver rotor from its normal alignment with the stator field results in a torque proportional to the degree of rotor displacement from its normal axis. This torque reaches its maximum value at 90 degree displacement with a polarized rotor, and at 45 degrees with a nonpolarized rotor. The maximum force obtainable is known as the "pull-out" torque. At rotor displacements beyond this pull-out value, the torque decreases and operation of the receiver becomes unstable. Unlike a-c devices, a d-c synchro may be operated continuously at any displacement within pull-out torque rating. Because rotor displacement increases the system error, the receiver is normally operated at as small a displacement from synchronism as possible.

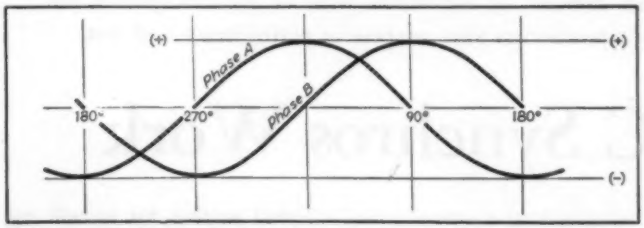



Fig. 2—Sinusoidal phase distribution of the electromotive force in the windings of the simple d-c receiver, Fig. 1, as created by the transmitter.

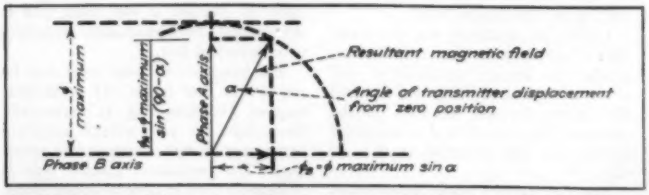



Fig. 3—Magnetic field set up in the receiver at any instant is the resultant of the magnetic fields produced by the A and B phase currents.

### Backlash or "Dead Band" Operation

In control applications requiring appreciable torque, the transmitter of a d-c (or an a-c) synchro will be a number of degrees out of step with the receiver before the latter will follow. When the direction of rotation is reversed, the transmitter must be moved through twice this number of degrees

before the receiver again will follow. The amount of transmitter travel required to produce motion of the receiver in the reverse direction is known as the "dead band" of the system; it is the lost motion or error, comparable to backlash in a gear train. Synchro units should be selected and so arranged mechanically as to result in the smallest possible dead band.

### Speed-torque Characteristics

Synchro units can be used, within limitations, as remote-controlled, variable speed devices. The efficiency of a synchro, as a motor, is poor and the power output is strictly limited. It is, therefore, necessary to know the speed-torque characteristics of a unit to determine its suitability as a motor device.

Receiver torque available when the unit is at stand-still corresponds roughly to the torque of a motor when its rotor is blocked. This maximum torque, Fig. 4, is commonly referred to as "static torque".

While the d-c receiver is in motion, its maximum available torque may be considerably less than its static torque, depending upon its speed of operation. As the receiver speed is increased, the torque decreases until it reaches a limiting value just sufficient to overcome receiver mechanical losses, the available output torque then being zero. Application of a mechanical load, or an attempt to increase speed beyond this point, will cause the receiver to pull-out of synchronism with the transmitter and cease to function as a synchro.

The speed at which this action occurs is called the "no-load pull-out speed" of the system. The operating characteristic of a receiver showing maximum available torque at various speeds is its "dynamic torque characteristic"; it is generally represented graphically, as in Fig. 5, by a speed-torque curve. The shaded area under the curve represents the maximum operating range of the receiver. It should be noted that as soon as the receiver rotor stops, its available torque reverts to maximum static torque. Both static and dynamic torque characteristics of synchro systems must be considered when selecting the proper units for a specific application.

### What to Consider When Applying D-C Synchros

#### Type of function

Although synchros have almost unlimited applications in various circuits, mechanical arrangements, and combinations with other equipment, their primary function breaks down to either:

1. Indication (lo load)
2. Control (torque load)

#### Type of Operating Cycle

1. A simple motion of the transmitter may be required to operate a receiver without further functional changes in the system. This is known as an open cycle system.

2. An automatic cycle may be desired, in which a definite sequence of functions is performed while the synchro system is being reset to a predetermined position. This is a closed cycle system, commonly known as a servomechanism. (For a comprehensive analysis of servomechanism theory see: "Dynamic Behavior and Design of Servomechanisms" G. S. Brown and A. C. Hall, ASME *Transactions*, Vol. 68, No. 5, July, 1946.)

### Determining Job Requirements

For the simple applications of indication or control, particularly for open cycle systems, manufacturers' engineering literature and catalog data, in general, provides sufficient information to choose a suitable combination. In more complex applications, manufacturers' experience will be of real value to the synchro user. To arrive at the best solution to a specific problem, the following minimum information is required:

1. Type of power source available.
2. Basic control or indicating function desired.
3. Required accuracy of response.
4. Torque requirements and inertia of controlled devices.
5. Operating speeds during various parts of control cycle.
6. Listing of any special requirements for open or closed cycle duty.
7. Listing of unusual operating limitations such as space, temperature, atmospheric conditions, power, or other conditions.

Both a-c and d-c synchros have advantages and limitations that must be considered when a selection is to be made. The choice of either a-c or d-c synchros for a given application should be based upon the preponderance of advantages offered by one or

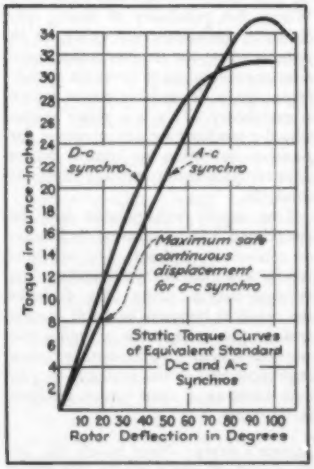



Fig. 4—Static torque of d-c and a-c synchros over a range of deflection.

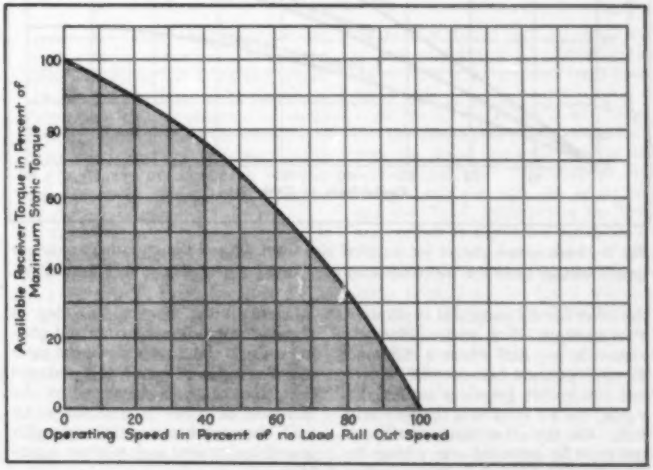



Fig. 5—Dynamic torque characteristic of a sinusoidal d-c positioner system. The shaded area represents the maximum operating range of the receiver.

**Table I—Comparison of A-C andD-C Standard Synchro Devices**

**Based on Units of Equivalent Cost and Physical Size of Receiver**

| Characteristic | A-C Synchros | | D-C Synchros | |
|---|---|---|---|---|
| | Transmitter | Receiver | Transmitter | Receiver |
| Physical size | Larger | Equal | Smaller | Equal |
| Operating power requirements | Variable—Depends on torque output | | Fixed—Independent of torque | |
| Life expectancy | Greater | Less | Less | Greater |
| Maximum distance between units | Limited to comparatively short distances by line impedance | | Limited only by resistance in lines | |
| Tendency to hunt | Present | | None | |
| Thermal effect of blocked receiver rotor | Windings overheat | Windings overheat | No effect | No effect |
| Effect on system accuracy with blocked receiver rotor | Accuracy of balance of system impaired | | No effect | |
| Effect of varying number of receivers in circuit | System accuracy unaffected | | System accuracy impaired—unless circuit is rebalanced | |
| Torque reaction on transmitter | Equal to receiver torque | | None | |
| Torque amplification | | No | | Possible |
| Maximum receiver torque available | | Greater* | | Less |
| Number of conductors between units | 5 | | 4 | |
| Noise level | A-c hum | A-c hum | None | None |
| Suitability for high speed rotation | Better | Poorer | Poorer | Better |
| Maintenance required | Less | More | More | Less |
| Dynamic differential application | Better for most applications | | Can be used at relatively low operating speeds | |
| Static differential applications | Used exclusively | | Not suitable | |

* Continued operation of a-c synchros at maximum torque beyond rated rotor deflection will result in over-heating of windings and possible burnout.

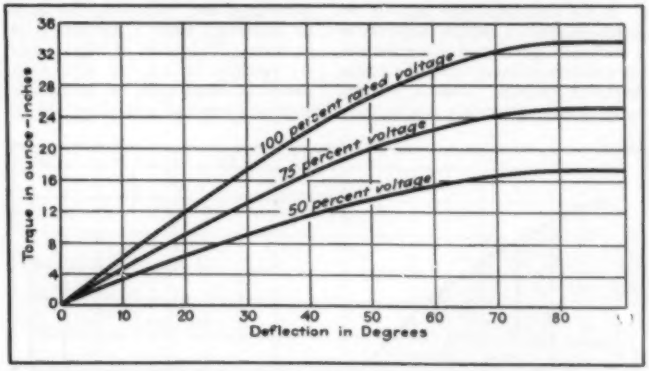



**Fig. 6—Static torque curves for a typical sinusoidal d-c receiver operating at various supply voltage show the comparative torque stability under line voltage fluctuations.**

the other for the particular application. For example, if a static differential system is required where a difference in rotor position between the receiver and transmitter generates an electrical signal, the a-c synchro is the only solution. On the other hand, where control must be provided over a long distance with a high degree of accuracy, the d-c synchro would be superior.

Where accuracy greater than that inherent in the receiver, ±1 deg, is required, special construction and gearing is used. Because many of the more common types of small gear reducers have too much backlash when the direction of travel is reversed under load, some synchro manufacturers offer geared transmitter and receiver assemblies.

The best grade of instrument gears of at least 64 pitch must be employed. Extreme care must be used to minimize backlash in the gear assembly. Eccentric bearing pins may be used to provide adjustment between gear centers. The bearings for the most critical applications are usually of the jewel type, with the shaft ground to a needle point. Often the gears are assembled tight, then packed with a disintegrating type of lapping compound to remove any high spots that may be present.

This lapping-in process must continue until the gears run with their minimum friction. Some applications call for a spring loaded gear assembly, or other suitable methods to eliminate backlash. The receiver torque needed to overcome friction will require a displacement of the rotor from the exact electrical axis established by the stator pole field. A system error is thus introduced, and it can be reduced only by reducing the system friction.

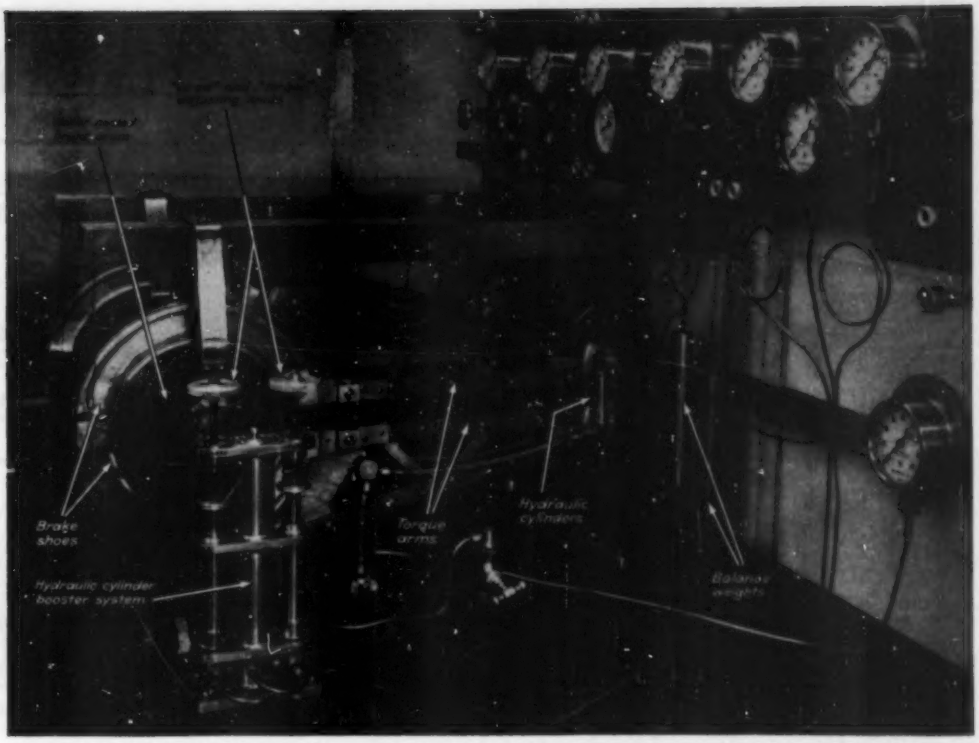
Where a high accuracy is required, the transmitter must be mechanically connected as close as possible to the element whose movement is to be indicated, rather than to a driving motor. Otherwise, additional displacement errors are introduced.

### Power Source Characteristics

Whenever a synchro transmitter moves more than one revolution after a power failure, the system falls out of synchronism. Upon the return of power the two units fall into step; but there will be an error of at least one revolution, therefore, requiring mechanical readjustment of the circuit. If the operator is not aware of the power failure, and the indication or control is a critical function, the results may be serious. Where this possibility of losing synchronism between units exists, as in systems where the receiver makes more than one revolution to cover the operating range, a dependable power source is mandatory. This is a prime reason why d-c synchros are advantageous for positive indication or control where uninterrupted battery voltage supply is available.

Low supply voltage also must be considered where accurate indication or control is required. D-c synchros are far less affected by fluctuating line voltages than a-c units. Fig. 6 shows the relation between available torque and supply voltage for a typical d-c receiver system. Positioning accuracy is proportional to the available torque, and therefore a steep torque gradient is desirable.

EDITOR'S NOTE: Next month the authors will discuss a number of different applications of d-c synchros to control, indication, and signaling devices.




HYDRAULIC BOOSTER SYSTEM at left actuates pistons in two pairs of torque-arm control cylinders. "Load" cylinders are located near right end of arms; "damper" cylinders (not shown) are mounted vertically inside the web of right hand pedestal.

# Precision Mechano-Hydraulic Dynamometer

HIGHLY ACCURATE MEASUREMENTS of torque loads up to 3,000 in.-lb can be made with a mechano-hydraulic dynamometer developed in England. The load fluctuations that characterize mechanical prony brakes are damped by a hydraulic system composed of two main pairs of cylinders. Precise torque readings result because the torque-friction curve becomes nominally "flat" instead of "steep", as in plain friction brakes.

The load to be measured is transmitted through a drive shaft that carries the water-cooled brake drum shown above. Two brake shoes that encircle the drum are pin-connected to the torque arms. The latter are linked together near their inner ends and are free to move up and down at their outer ends between the pistons of two vertical "damping" cylinders mounted inside the pedestal at the right.

Hydraulic pressure in the "load" cylinders at the outer ends of the arms forces the brake shoes against the drum. As friction is built up between shoes and drum, the shoes and torque arms follow the rotation of the drum. Depending on the direction of drum rotation, one of the arms moves into contact with the upper or lower "damping" cylinder piston, which prevents fluctuations or excessive displacement of the arm assembly.

The hydraulic booster system at lower right produces pressure for the two pairs of cylinders. Center column is a reservoir that supplies fluid to the "load" cylinder on one side and the "damping" cylinder on the other. Each of the latter has its own coil spring and control knob that form the adjusting mechanisms for the pumps.

Operation of the dynamometer is simple. When the drive shaft is turning, the two knobs are adjusted so that the pumps pressurize the "load" and "damping" cylinders. A pilot lamp lights when the "damping" cylinders balance the torque built up in the end of the working arm. Readings are taken from a torquemeter and power calculated.

Action of the forces is as follows: As the brake shoes move clockwise with the drum, the upper torque arm contacts the "stop" on the upper shoe. Torque acts through the upper arm and the "load" cylinders to the lower arm, which is supported on the lower "damping" cylinder piston. At the same time, the lower arm is a simple lever pivoted on the lower shoe and acts as a friction-controlling member. The amount of friction between shoe and drum is therefore dependant on the difference between opposing pressures on the "load" pistons and lower "damping" piston.

There is little, if any, limit to the capacity of this type dynamometer. The design is suitable for handling a full range of torque loads from low speeds to 2,000 rpm, maximum.

# Fifteen Types of Mechanical

Constructions of tubing butt joints not requiring welding are shown. Most of these, Figs. 1 to 10, can be assembled and disassembled without damaging any of the component parts of the joint. Others, Figs. 11 to 15, are either detachable or permanent, depending on some of the details of the construction. This data has been prepared by the Product Development Committee of the Formed Steel Tube Institute, Cleveland, Ohio.

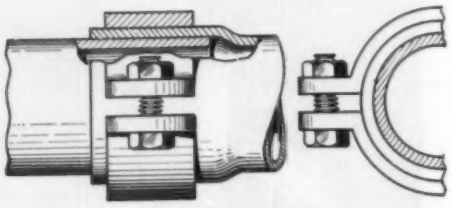


Fig. 1—Telescoping clamp fastening. There is no reduction in the inside diameter of the tube.

Fig. 2—Threaded sleeve fastening. This joint can be used either in structural members or in piping systems.

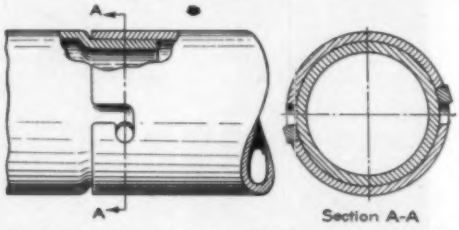



Fig. 3—Bayonet type fastening. This is an easily assembled joint of fixed length for attaching two tubes.

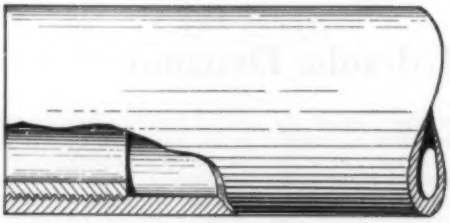


Fig. 4—Standard inside diameter thread connection. This type of joint is usually used in piping systems.

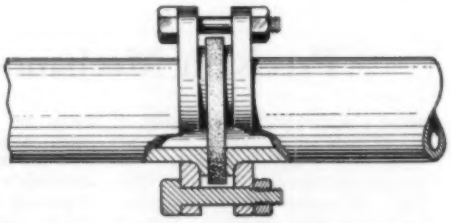


Fig. 5—Square flange gasket. This can be used as a fastening for pipes or ducts carrying liquid, air or gas.

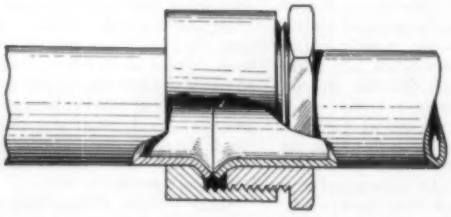


Fig. 6—Stuffing box type connecting clamp and 45 deg flange. This joint is used for pipes carrying liquids.

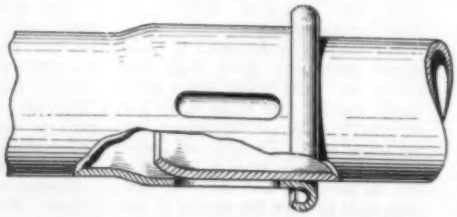


Fig. 7—Friction type joint. This easily assembled and disassembled joint is often used in vacuum cleaners.

# Joints for Tubing

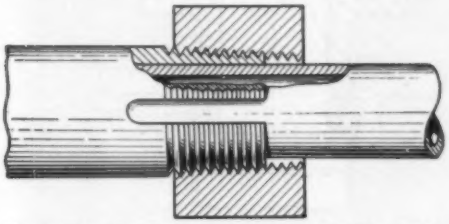


Fig. 8—Tapered locknut type joint is advantageous when adjustments in overall length are often required.

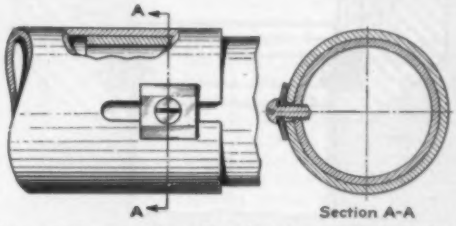



Fig. 9—Clip type joint. The clip curves away from the tube. Its flexibility facilitates longitudinal adjustment.

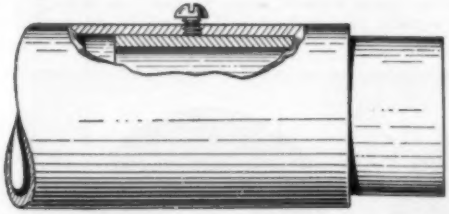


Fig. 10—Set screw. This fastening is a simple, inexpensive method of joining where adjustment is necessary.

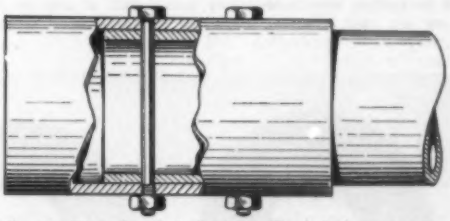


Fig. 11—Riveted or bolted joint. The bolted construction facilitates frequent assembly and disassembly.

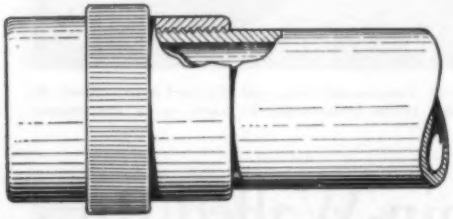


Fig. 12—Self-tapping threaded coupling. Thin walled tubing can be used. Occasional disassembly is possible.

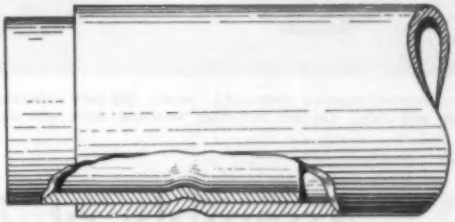


Fig. 13—Indentation type joint. The depth of the dimple determines whether or not it is detachable.

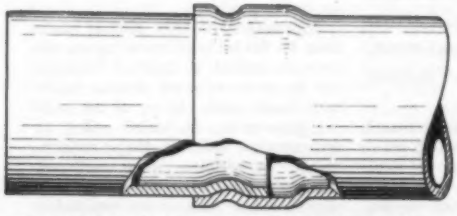


Fig. 14—Beaded joint assembly. The inside bead is preformed, and the outside bead is made after assembly.

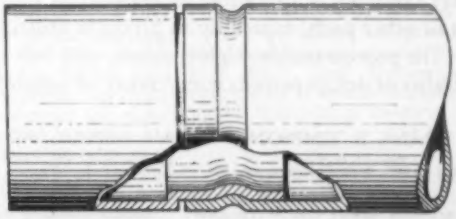


Fig. 15—Beaded assembly. This is like the assembly of Fig. 14 except that the outside diameters are matched.

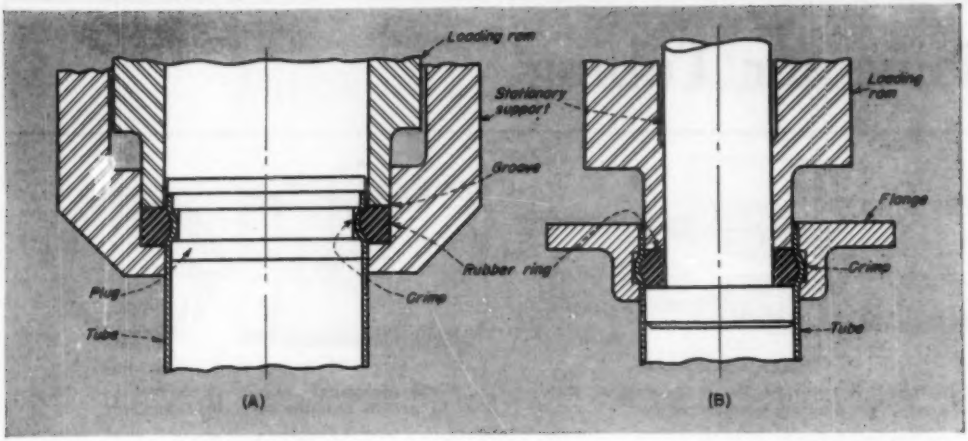



Fig. 1—Methods of application: (A) External crimping, showing assembly of tube and plug; (B) internal crimping—compressed by loading ram, rubber ring forces wall of tube to deform into groove in flange. Since lubricants and hydraulic fluids are not used, crimping rings can be given large clearances, allowing easy insertion and removal of the work.

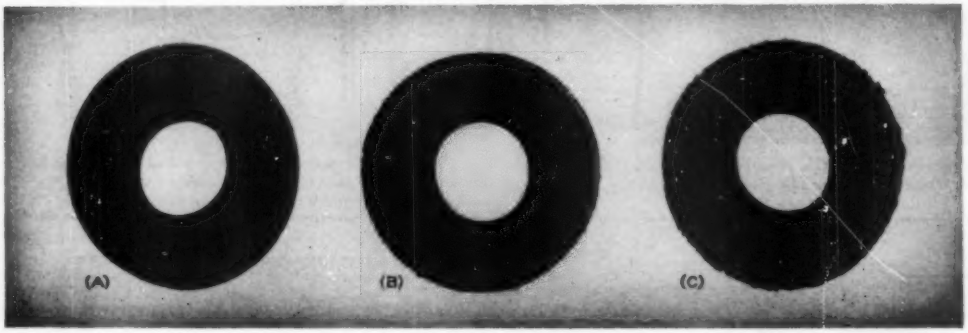



Fig. 2—Neoprene crimping rings: (A) Unused; (B) used approximately 25 times on each side; and (C) used approximately 40 times on each side. The last two rings were used in a split die, which is the worst condition likely to be encountered.

# Assembly of Thin-Walled Parts

**Rubber crimping is applicable to assembly of thin-walled metal tubes or other parts, especially in products utilizing fluid actuation. The process enables tighter joints, with low residual stress. Flexibility of design permits wide variety of junctures and shapes.**

FRANK R. SIMPSON
Research Engineer
The Franklin Institute Laboratories

THIN-WALLED METAL PARTS can now be assembled by crimping at high pressure, using rubber rings that are constrained on all sides except the working surface. Properly formulated and supported, rubber can transmit pressures in the order of 30,000 psi—sufficient to distort shapes of steel, brass and other metals.

Rubber crimping can lessen the disadvantages of older methods of assembling thin sheets, such as soldering, brazing and welding. Residual stresses and fluid leakage at joints, resulting from bad shop practice, are avoided in the newer process.

Advantages of this method stem from its flexibility. Depending on the pressure applied, all types of junctures can be produced from flexible joints to hydraulic seals. Shape of the locking grooves can be varied widely to accommodate different design requirements. In addition, when parts are connected by rubber crimping, only slight contour changes are required—and these changes frequently aid design simplification.

Rubber crimping is most applicable to sheet metal 0.030 in. thick, or less;

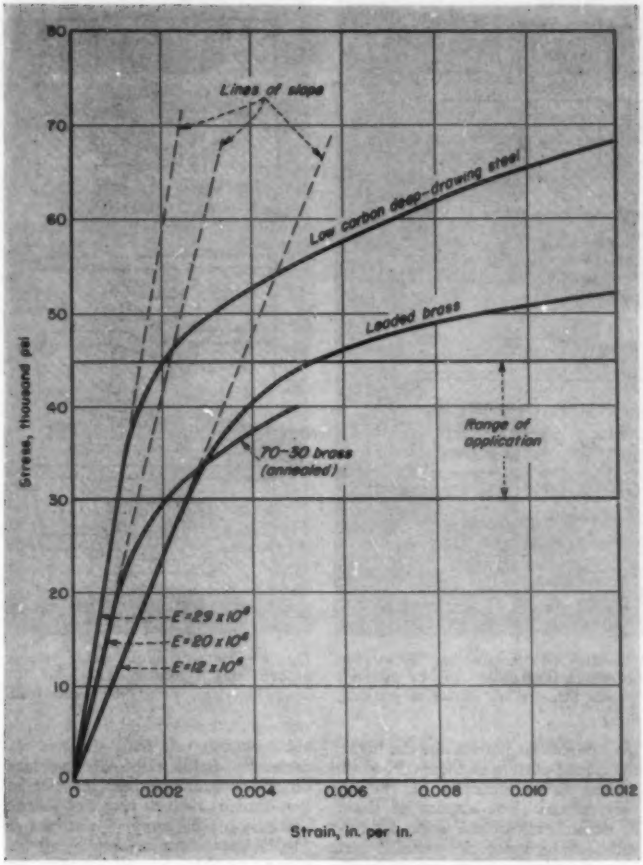



Fig. 3—Typical stress-strain curves for three metals commonly used in this type of forming. For satisfactory results, material must be stressed into the plastic region.

# by Rubber Crimping

occasionally it is used on sheets up to 0.100 in. thick. Main field of application of this method is in assembly of tubing for carrying of liquids and gases. Fluid-tight characteristics of rubber-crimped joints were tested by filling a structure, made by assembling 0.025 in. metal tubes, with air at a pressure of 100 psi. The structure was completely immersed in water; no air bubbles were observed, even after one month of immersion. Fluids of almost any viscosity can be used in such structures, including hydraulic oils, and the pressure such a system will withstand is limited by the thickness and kind of metal used in the tubing.

Suggested application of this process is in manufacture of products requiring tightly bonded joints, such as containers, thermos bottles, kitchen utensils, fire extinguishers, electrical fixtures, radio equipment, and pneumatic circuits for cash registers, machine tools and similar equipment.

## The Method

Rubber crimping is accomplished by applying external or internal pressure on the metal surface to be deformed, using either a rubber plug or ring, which acts as an hydraulic medium. Pressure will deform the metal in the direction of unrestrained movement. As shown in Fig. 1(A), the metal shell or tube is forced into a mandrel groove by external pressure of a rubber ring restrained in a holder; a hollow piston loads the ring. Fig. 1(B) shows a similar arrangement in which force is applied to the shell from within. Rubber rings offer two advantages in production. Because rubber returns to its original shape after each loading, crimping rings can be given large initial clearances in the press equipment. Since wear is not a major factor in effective operation of the equipment, clearances between loading piston and holder, and the shell and holder can be as great as 0.015 in. Also, because there is no lubricating or hydraulic liquid to contend with, the work can be easily inserted and removed, without the complication of special seals and similar units.

For deforming large parts, the horizontal press method has been found most satisfactory. Vertical feed is preferred in processing small parts because it makes advantageous use of gravity. With complicated equipment, such as multiple presses having automatic feed, either vertical or horizontal operation can be used.

Rubber used for rings and plugs must be hard, and give a minimum of "fringing" under high pressures (Fig. 2). It must also be flexible enough to flow as much as the work requires, and not hard enough to split or crack. High fatigue endurance under repeated compression is also mandatory. There are several suitable types of thick rubber sheet or rod obtainable commercially. A neoprene rubber with specification No. SC 718, ASTM D-735-48T, has been used with excellent results. Two important requirements of this rubber are Shore hardness of 70 and tensile strength of 18,000 psi.

Required properties of rubber for these applications varies with the type of material being deformed. Metals having high yield points require a rubber forming member with less ductility and greater resistance to plastic flow than that required for low yield metals, since displacement or deformation is usually in direct proportion to ductility of the metal.

## Materials

The metal to be shaped should be ductile, with as low a yield point as is consistent with the strength required in the assembly parts. Ordinarily, the hardness of these metals should not be greater than Rockwell B 60. Deformable metals such as annealed

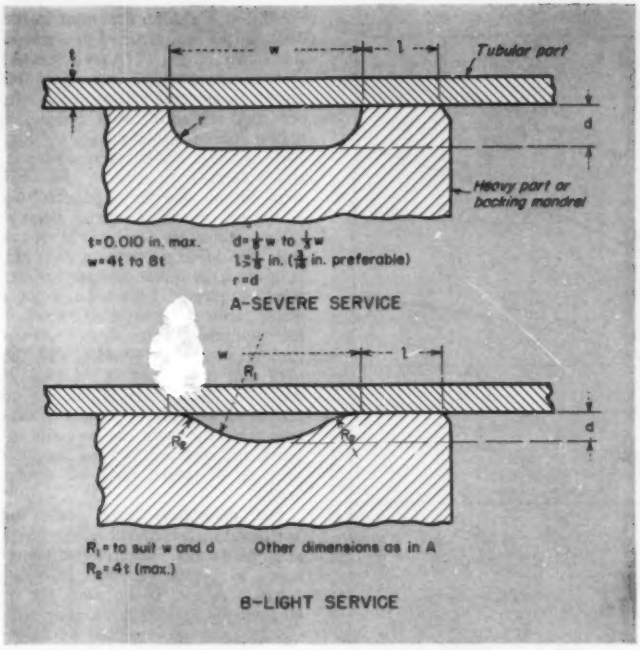



Fig. 4—Groove designs for severe and light service: (A) Suitable for shocks from rough handling or in operation; (B) suitable where separability may be desirable at fixed loads. The latter is desirable for metals that are susceptible to cracking.

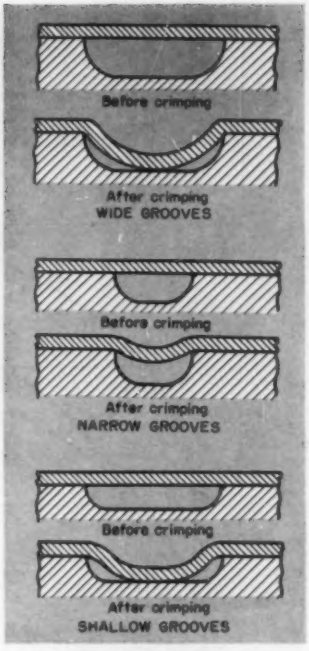



Fig. 5—Crimps resulting from various groove sizes (sharp-edged contour for severe service), using the same load.

copper and tin, will work more readily than harder brass, aluminum or steel; but these materials will deform satisfactorily if the amount of displacement and the angle of bend is low. Recommended groove dimensions should take care of these requirements, but all materials must be uniform in structure and hardness. Cracks, and irregular distortion result from uneven hardness in even the most ductile metals.

The stress-strain curves in Fig. 3 compare three typical metals used in this type of forming. The steeper the straight line portion and the higher the curved portion of these curves, the greater is the difficulty of forming these metals. The amount of strain, or deformation of the work, must be sufficient to stress the material well into the plastic region which is the horizontal portion of the curves. Working of the metals in the plastic region greatly reduces the recovery.

Experiments with various metals indicate that a compressive stress on the rubber of 45,000 psi need not be exceeded, and that a good average working pressure for most metals is about 30,000 psi. This stress is obtained by dividing the effective load on the hydraulic ram by the area of the loaded rubber projected along the axis of the ram. The curves in Fig. 3 show a pronounced bend between 20,000 and 45,000 psi for strains up to 0.005 in., which is sufficient to give plastic deformation. Applied pressure should also be determined by tightness of joint desired.

## Design Recommendations

Wall thickness of parts to be assembled by rubber crimping should

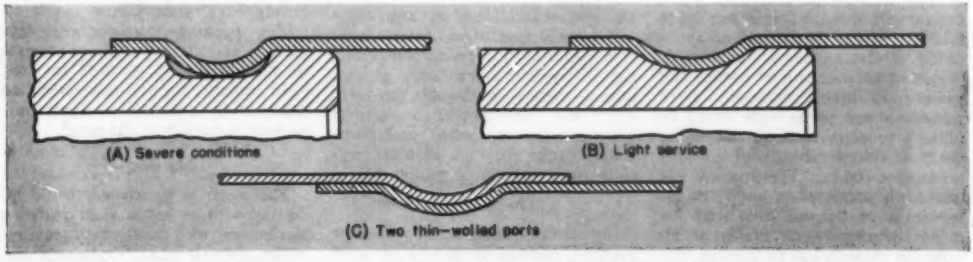



Fig. 6—Crimp designs for various conditions: (A) Sharp edges for severe service requiring an hydraulic seal; (B) rounded groove edges, where sealing is not important; and (C) thin-walled parts must be crimped together over a heavy mandrel. Proper proportioning of groove radii, wall thickness and groove depth allows a wide range of holding conditions.

not exceed 0.100 in.; and the crimping groove should be of large enough section to raise the bending stress of the metal above the elastic limit.

Ratios of groove width to wall thickness and groove depth depend on the requirements of the joint for leakage resistance, torsional strength, axial stiffness and separability. Once the wall thickness has been selected to suit the requirements of the product, minimum groove width, $w$, can be safely approximated from 4 to 8 times the wall thickness, $b$; and the depth, $d$, can be taken as 1/3 to 1/5 $w$ for maximum service requirements. For severe service the radius, $r$, of the corners of the groove should be equal to the depth, $d$.

Fig. 4 shows two typical groove designs for severe and light service requirements. In Fig. 5(*B*) sharp corners on the edges of the groove are removed; thus, the groove is designed as a curve of constant radius with two other small radii to relieve the corners. This groove is particularly desirable for use with metals that are susceptible to cracking or splitting.

Rubber crimping can be varied widely, from a simple ring groove to complicated types of locking using a series of rubber rings or plugs. Applied properly, the method of locking two parts by deforming one to conform with another gives a joint stronger than any obtainable by other mechanical methods, because the forming load is distributed more equally over the entire area affected, resulting in a more uniform contact.

Joint tightness however, is limited by the degree to which the mating parts can be bent to conform to each other, particularly along the groove edges. Fig. 5 gives typical recommended bending forms for wide, narrow and shallow grooves. The crimped metal never fully fills the grooved mandrel surface. More deformation is allowable with wide groove design; and conversely, the narrower the groove the less deformation the metal can withstand before cracking.

Photomacrographs taken through the crimping groove show the unrounded edges of a groove for light service bedding themselves deeper into the metal as the crimping pressure is increased, forming a seal similar to the type found in valve seats. Sometimes the spring of the crimped portion can be used to compensate for differential expansion between parts made of dissimilar metals.

Typical variations in crimp design are shown in Fig. 6. A design suitable for moisture sealing in severe service and for parts liable to shock loads is shown in *A*. Drawing *B* illustrates a crimp for light service where strength is not a major factor, or where two parts must separate on applying a predetermined load. A wide range of holding conditions can be met by proper proportioning of groove radii, wall thickness and groove depth.

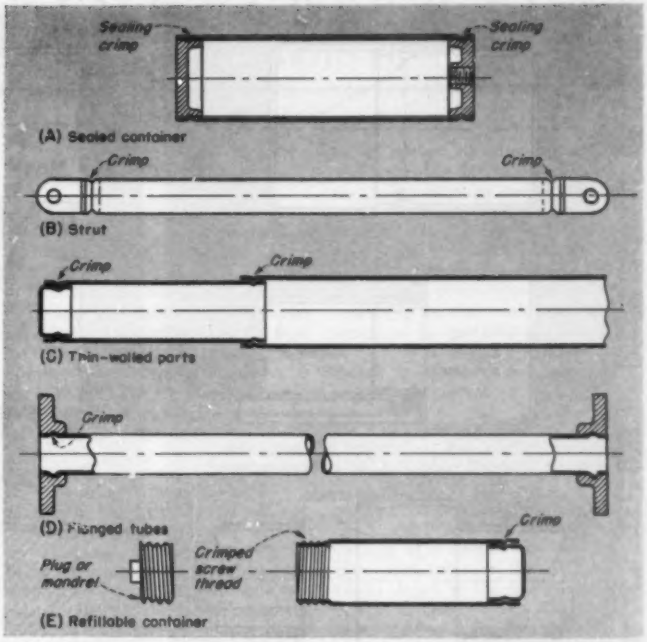



Fig. 7—Some rubber crimping applications. In (C) backing mandrel is required to support two thin-walled parts during crimping. To form parts in (E), collapsible mandrel is used and loading pressure is limited to facilitate removal of mandrel.

Five different types of rubber crimping applications are shown in Fig. 7. Thread forming by rubber crimping requires the deformation of each part separately. The operation is essentially pressure forming rather than crimping. The thread in the thin-walled shell, Fig. 7(*E*), is formed on a solid mandrel; a plug or other part of similar thickness with a matching thread can be joined to it. When a threaded connection with a loose fit is desired, clearance can be obtained by using male and female forming mandrel dimensions of different sizes; equal pressure is used on both threads. Thread clearance can also be varied by forming at a pressure less than 30,000 psi. To avoid sharp bends and the subsequent danger of cracking, a rounded rather than V-type thread should be used.

By simple internal or external rub-

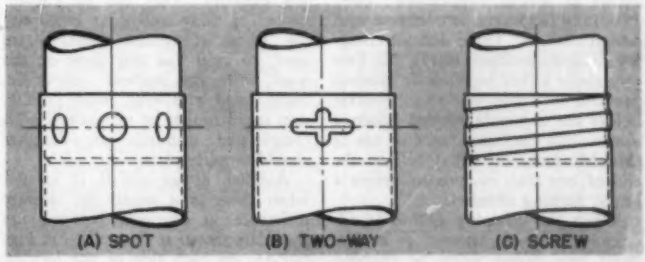



Fig. 8—Special types of locking shapes produced by rubber crimping: (A) Spot type is used where sealing is not required; (B) two-way type resists specific axial and torsional loads; and (C) screw type is for parts subject to frequent disassembly.

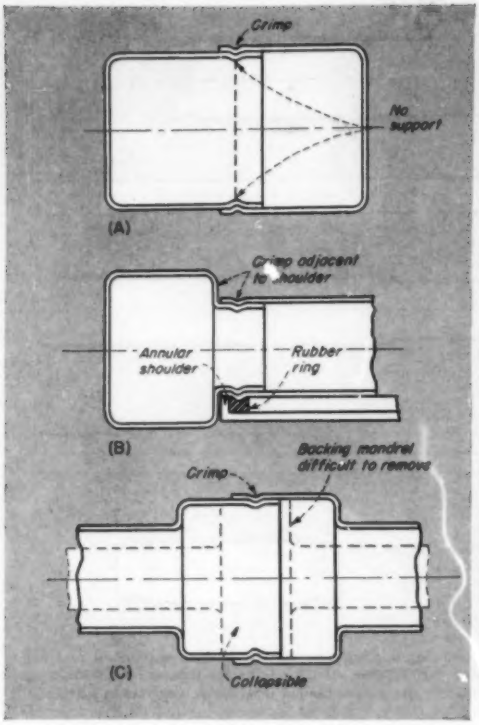



Fig. 9—Designs that are inapplicable to rubber crimping, or difficult to apply. Limitations of (A) and (B) can be avoided only by design changes. Problem (C) can be solved by use of a collapsible mandrel, but this is often difficult and expensive.

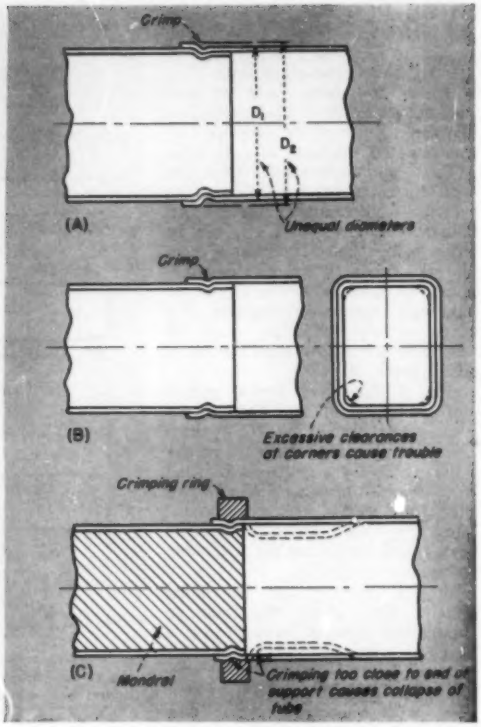



Fig. 10—Design pitfalls. Unbalanced thrusts, excessive local clearances, and adequate backing must be provided for. High loads are created by the rubber rings, which can cause collapse of the tube if the pressure is on an unsupported section.

ber crimping, shapes of the formed areas are not limited to the circumferential type. Crimp shapes, such as those shown in Fig. 8, can be readily produced for designs requiring both axial and rotational constraint of mating parts.

### Limitations

Some of the limitations of rubber crimping are inherent in the requirements of special applications; other inhibiting factors can be overcome with design changes. Three difficult crimping designs are shown in Fig. 9. Two thin shells locked together by external pressure only, Fig. 9(*A*), will buckle before the crimp is formed. Such a design can be modified to use a threaded lock, or redesigned so the end of one shell is open to receive a heavy, backing mandrel.

When the crimping groove is adjacent to a large diameter, as in Fig. 9(*B*) the design must be changed to allow enough clearance between the shoulder and the locking groove to prevent the annular shoulder from being deformed by the expanding rubber ring. One effective way to get smaller clearance is to reduce thickness of the rubber ring; this reduces the necessary overhang of the backing shoulder, but is limited by the tendency of thin forming rings to crack under pressure.

Under other crimping conditions, such as in Fig. 9(*C*), it may be difficult, or impossible to remove a backing mandrel. This can be circumvented by using collapsible mandrels; but where segmented mandrels are used, an axial line may show on the work when the segment corners become round with wear. Since production speed cannot be maintained with complicated mandrels the designer should simplify parts.

Another design pitfall is created when there is a small, but definite difference in diameter, between the shoulders shown at $D_1$ and $D_2$ in Fig. 10(*A*), on each side of the locking groove. Although this difference may appear inconsequential, a large axial thrust on the thin-shelled part, or an unbalanced load on the mating part will force the work away from its correct position. Unsupported axial pressures on each side of the crimping groove should be balanced as nearly as possible.

When non-cylindrical work is subjected to rubber crimping, Fig. 10(*B*), the desired results might not be obtained if clearances at the restraining surfaces on each side of the rubber ring exceed about 1/64 in. when accurate fitting of the forming holders is difficult.

A common mistake, Fig. 10(*C*), is to place the forming ring too close to the end of the solid part, or backing mandrel, so that the rubber exerts pressure beyond the supported section and collapses the unsupported tube. It is possible to reduce the distance between the edge of the groove and the end of the supporting mandrel to 3/16 in. A smaller clearance is not practical because too much precision would be required to locate the work with reference to the edges of the forming rubber.

# ENGINEERING ABSTRACTS

FOREIGN AND DOMESTIC ARTICLES

## New Fluid for Crack Detection

**Abstracted from "Crack Detection, A Development to Give Improved Definition". Automobile Engineer (London) December, 1949.**

IMPORTANT FEATURES of magnetic fluids are good color contrast between the particle formations and the surface of the articles, and slow gravitation of the particles in the suspending medium. Magnetic fluid containing black particles is therefore most successful on brightly finished surfaces. It is not so successful on dark surfaces such as those found on unmachined forgings, and stampings, unless white paint is applied to the surface before the fluid is applied.

Alternatively, a detecting fluid containing colored particles, for example the red magnetic oxide which forms a contrast with the surface under test, may be used. However, where a black and white contrast is considered to be best for dark surfaces, a white fluid is desirable. In fact, the demand for such a fluid has persisted in spite of the existence of the red fluid.

In the past, experiments with nickel powder in paraffin have been made in attempts to produce white magnetic fluid. They were successful magnetically, but the grey color and rapid gravitation due to the greater density and particle size rendered the method impracticable. Mixtures of a white powder such as French chalk and normal black fluid have failed, since most white powders become dark when wetted with paraffin.

### Aluminum Powder Used in New Fluid

A new fluid developed in the Research Department of Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, employs a white additive or "tracer" that retains its whiteness when immersed in paraffin. While the use of any powdered light-colored metal of low density would suffice, the use of finely divided aluminum has been particularly successful. The whiteness of the aluminum is not impaired by wetting with paraffin, methylated spirits or other thin oil vehicle, and the lightness and fineness of the particles ensure a sustained suspension. It has been found that the best results are obtained by ball-milling a mixture of approximately equal parts by volume of aluminum and iron oxide prior to dilution with paraffin or methylated spirits, according to the type of base.

Tests with specimens known to contain cracks have shown that there is no reduction in the sensitivity of the fluid through the addition of the aluminum powder. Surface cracks are shown as white lines due to the presence of the aluminum particles carried to the defects with the magnetic particles. The whiteness is greatly improved by allowing time for draining. The fluid may be used in an immersion bath, in a pressure oiler or by pouring over.

Where large numbers of components such as unmachined forgings are being magnetically crack-tested by the white-paint black-fluid technique, the substitution of the white magnetic fluid method should save valuable time.

Two additional effects that have been noticed with this new fluid may be of interest to other investigators. The first is that convection currents in the fluid, although caused by quite small temperature differences, are rendered easily visible by the circulation of the aluminum particles. Secondly, the effect of moving a permanent magnet in the vicinity of a beaker containing the white fluid is to produce variations in appearance. The shade of the fluid may be quickly made darker or lighter by a suitable movement of the magnet.

### Test Results

In the original article, the authors reproduce three photographs of metal parts to which this crack detection method has been applied. First is a small shaft, and the other two are pictures of a round piece before and after immersion in the fluid. The cracks shown in the third picture are typical grinding cracks, the smallest usually detected by the method. In both the residual was sufficient for the crack detection, and adequate draining was allowed.

## Magnetic Clutch Spindle Drives

**Abstracted from "Magnetic Clutch Spindle Drives Permit Wide Variety of Special Functions With Little Extra Equipment", by L. A. Leifer. Paper presented to the Machine Tool Forum, April 1949, at Westinghouse Electric Corporation, Buffalo.**

THROUGH THE USE of a direct acting magnetic clutch the spindle drive of the standard turret lathe has been improved, the useful speed range of the machine increased, and certain difficult and special drive applications have been successfully accomplished.

One part of the clutch device, Fig. 1, is an angular shaped magnet element containing the energizing coil surrounded on three sides by a shell of magnet iron. The fourth side is covered by a special friction material. The second part of the device is a segmental armature that completes the magnetic circuit and bears against the friction surface.

Approximately 0.1 sec after impressing 90 volts d-c across the magnet terminals, the clutch is in full engagement and drawing 0.3 to 0.4 ampere. During the 0.1 sec while the flux build-up takes place, the clutch gradually increases its contact pressure, thus automatically providing smooth acceleration. The 35 watts of energy required to engage and maintain the clutch in engagement can be obtained from small disk type rectifiers and controlled through switching units of small size and capacity.

Among the applications for the magnetic clutch discussed are its use on: A single spindle automatic lathe;

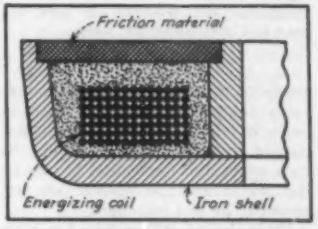



**Fig. 1—Electromagnet unit for clutch or brake consists of an energizing coil imbedded in a filler material contained in an iron shell faced with friction material.**

a machine for turning rope grooves in hoist drums; saddle type turret lathes with hydraulic speed selectors; and a machine for screwing threaded valve seat inserts into machined gate valve bodies.

In general, the use of the magnetic clutch and brake offers definite advantages for machine tool spindle drive control. These advantages include: Smooth, shockless acceleration and deceleration; ease of adjustment of acceleration and deceleration rates; simplicity of control devices used for actuation of the clutches; direct, instantaneous response to actuating devices; and no necessity for adjustment for wear.

## Free Machining Steels

**From "Free Machining Steels" by W. Lee Williams, U. S. Naval Engineering Experiment Station, in the Journal of the American Society of Naval Engineers, August, 1949.**

FREE MACHINING STEELS usually obtain their superior machinability through high sulfur or phosphorus contents. It has long been known that these steels should not be used for critical structures, especially where dangers of fatigue or impact are present, or where high stresses occur transverse to the rolling direction. Nevertheless, they are employed in large quantities where the cost of machining is an important consideration.

Nearly all free machining steels are produced in bar form. The great majority are turned into parts, such as bolts, in which the major stresses are parallel to the direction of rolling. In such parts, the mechanical effects of the sulfur and phosphorus are expected to be at a minimum.

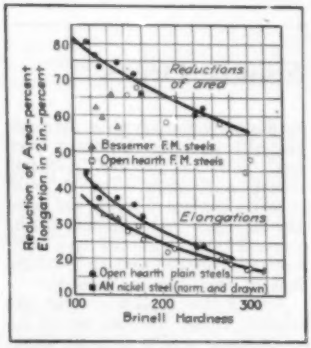



**Fig. 1—Relation of Brinell hardness to elongation and reduction of area for quenched and tempered steels.**

Only limited information has been published concerning the ability of free machining steels to deform and absorb energy prior to fracture. In two categories further research appeared warranted, and the U. S. Naval Engineering Experiment Station undertook an evaluation of: (1) The ductility of free machining steels stressed in the direction of rolling, and (2) the critical impact (embrittling) temperature when stressed in the direction of rolling.

In the experimental work, nearly all types of commercially produced free machining steels were treated as a general class, to determine whether sulfur and phosphorus were among the predominant influences on ductility and impact resistance. A second phase, not abstracted here, consisted of a study of three series of steels in which all known variables were held constant while the sulfur contents were changed.

The tensile and hardness characteristics were determined for each steel in each condition. The treatment and analysis of the data presented some difficulty because of the variety of types of steels. The ideal way to study the effects of sulfur would be to hold all conditions constant except the sulfur content. In this study, there were variations in all the other elements, including constituents not ordinarily determined. No control was possible concerning the foundry and mill practices used in production. Hence, the best which could be expected of an analysis would be an indication of trends and general differences between plain and free machining steels as or-

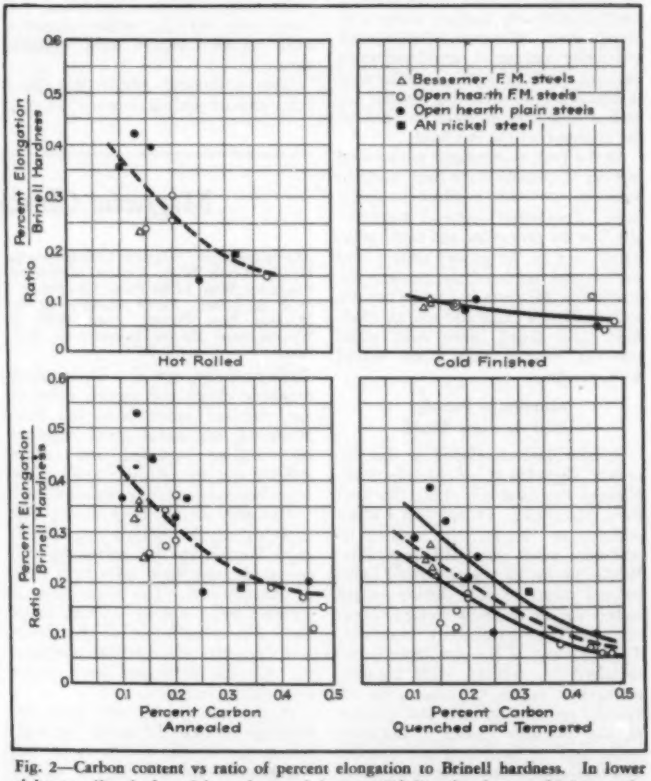



**Fig. 2—Carbon content vs ratio of percent elongation to Brinell hardness. In lower right, top line is for plain carbon and lower solid line for free machining steels.**

dinarily produced by the steel industry.

Steels, especially in the quenched and tempered condition, show a linear relationship between tensile strength and hardness. Also, sulfur and phosphorus have little effect on this relationship. In this respect the steels behaved as anticipated. Individual points in the graphs were drawn with symbols differentiating between free machining Bessemer steels, free machining open hearth steels, plain carbon open hearth steels and Class AN nickel steel.

One possible treatment of the ductility data is illustrated in Fig. 1, in which the percentages of elongation and reduction of area were plotted against the Brinell hardnesses of the quenched and tempered steels. It was possible to draw two elongation curves, one representing non-free machining steels and the other the free machining varieties. The elongations of the latter were distinctly inferior. In the reductions of area, a fairly good curve could be drawn for the plain steels, but the scatter was too great for the location of a curve representing the sulfurized steels. However, despite the scatter, it was evident that the points fell below the curve for the plain steels. Hence, as a class, the sulfurized steels showed less ductility in the quenched and tempered condition.

The type of graph in Figs. 2 and 3 was preferred, and was chosen for the principal presentation of data, because it related the ductility to the carbon content. Hence, it presented a clearer picture of the relationship of ductility to the composition range of AISI grades of steel under investigation. The ordinate scale showed the ratio of the percent elongation to the Brinell hardness (or the reduction of area to hardness). If two steels and the same carbon content and hardness, but different elongations or reductions of area, the one with the superior ductility would have the higher ordinate value. Likewise, since it has been shown that the tensile strength was a linear function of the hardness, the same difference would be observed with two steels of equal strength but different ductility. The graphs shown could distinguish between the ductilities of steels with equal hardness or strength over a broad range of carbon content.

Figs. 2 and 3 reveal that the graphs for the quenched and tempered steels contained two solid lines, one representing the trend of the plain carbon steels and the other of the free-machining steels. The latter were distinctly inferior with respect to ductility. It was possible to draw the broken lines to separate, almost without exception, the plain and free machining compositions.

The similar diagrams for the annealed and hot rolled steels presented too much scatter of test points to allow representative curves to be drawn. However, the broken lines once again divided fairly well between the plain and sulfurized steels. The trend was definitely toward lower ductilitly in the free machining varieties.

By contrast, the diagrams of the cold finished steels showed no significant difference between the two general classes of materials.

Standard Charpy keyhole impact tests of these steels were made at temperatures ranging down to —260 F. The object of the tests was to determine primarily the critical impact temperature, i.e., the temperature at which there is a change from a ductile to a brittle type fracture and a simultaneous marked drop in the energy required to rupture the specimen. In most steels the embrittling temperature was quite clearly defined. In others, the critical temperature covered a range of 30 to 40 F. In such specimens, the critical temperature was recorded at about the midpoint; such a selection was ordinarily associated with about a half ductile-half brittle appearance on the fractured surfaces of the specimens.

A review of the impact data indicated only a few trends. The quenched steels had lower critical temperatures than the same steels in other conditions of treatment. In general, the annealed condition was poorest in this respect, although a few minor exceptions were noted. The open hearth grades of free machining steels compared favorably with the open hearth grades of non-free machining steels. The Bessemer steels had higher critical temperatures than any of the others. Finally, the known beneficial effects of nickel were confirmed by the very low critical temperatures found for the Class AN steel in all conditions of treatment.

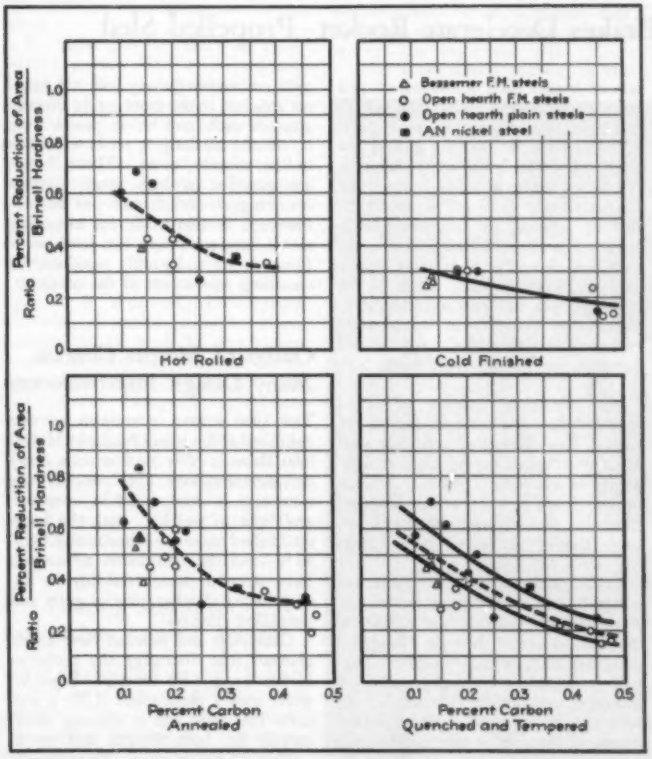
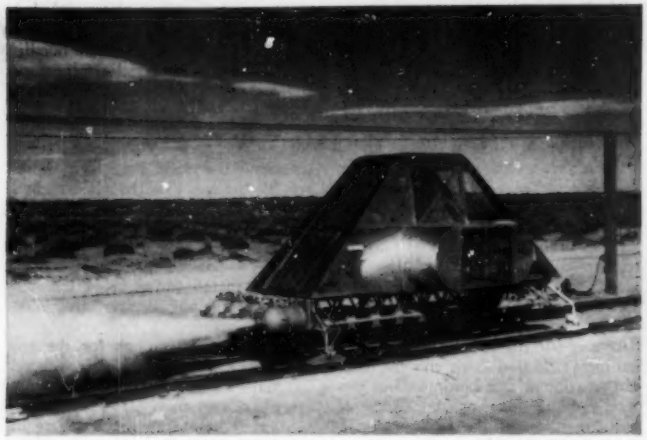
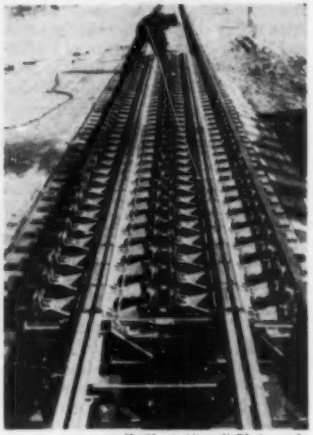



**Fig. 3—Carbon content vs ratio of percent area reduction to Brinell No. In lower right, top line is for plain carbon and lower solid line for free machining steel.**

# TECHNICAL NEWS





Northrop Aircraft Photographs

"HUMAN DECELERATOR" is propelled along quarter-mile track by one to four rockets. Nest of brakes in concrete road bed (right) bring 1,500-lb carriage to halt, exerting up to 50 G's force on volunteer or dummy strapped to seat within.

## Ninety Pairs of Brakes Decelerate Rocket-Propelled Sled

AIR FORCE VOLUNTEERS riding in a new "safety capsule" developed by Northrop for the Aero Medical Laboratory can now duplicate airplane crashes. But sudden death does not ride with them.

Known as the Northrop Air Crew Decelerator, the machine permits scientists to obtain the first accurate "stress analysis" of the human body, and to make accurate "test crashes" on safety devices intended to safeguard crew and passengers in airplane crack-ups.

The "human decelerator" consists of a 1,500 lb welded-tube carriage slipper-mounted on a 2,000 ft run of standard-gage railroad track and a 45 ft mechanical braking system believed to be the most powerful ever constructed.

In a test run, the volunteer, after a thorough physical examination, is strapped in position on the carriage. Instruments to measure forces and pressures are attached to the individual, his harness and seat. All data taken during the experiment are transmitted as radio signals and recorded in the control room beside the track.

The volunteer braces himself as 1,000 lb thrust rockets at the rear of the carriage are simultaneously fired. The carriage then roars down the track into the braking area where it is decelerated under controlled conditions.

Deceleration is accomplished by 45 sets of brakes each consisting of two pairs of clasp-type shoes installed in the road bed, beginning at a point 1,250 ft from the starting end of the track. The 180 brake shoes clasp 11-ft braking blades attached beneath the chassis of the carriage to apply the desired amount of retarding force. Brakes are actuated hydraulically and each shoe is capable of exerting a pressure of 33,000 pounds. Each of the braking units can be controlled individually to provide, in combination with one to four rockets, any desired variation in braking force from 5 to 50 G's.

An emergency braking system is installed near the extreme end of the track. This consists of a flexible steel cable stretched across the track at right angles to the path of travel. A hook on the front of the carriage engages the cable and tension applied to the cable through hydraulic reels brings the carriage to a halt.

Four accelerometers are attached either to the volunteer or to the carriage chassis, transmitting signals to the control tower through Northrop-designed telemetering equipment. Signals generated by stress gages attached to various parts of the volunteer's body also can be recorded. Photographic timing of test runs is provided by coils mounted at 25-ft intervals along the track, except in the braking area where coils are mounted every foot. A magnet attached to the front guide slippers actuates each coil as it passes over it, thereby flashing a series of lights in the control tower. These flashes are recorded by high speed cameras operating at 500 frames per second. Provision is also made for mounting movie cameras inside the carriage in forward, aft and profile positions for recording movements of the occupant.

## Outboard Motors Contain Many Design Improvements

THE 1950 MODEL OUTBOARD MOTORS exhibited at the recent National Motorboat Show in New York contain many design innovations. The "put-puts" are now easy to start, quiet in operation and light in weight. Both the long-established makers—Johnson and Evinrude—and the half-dozen newcomers have stressed maneuverability by incorporating clutches, neutral gears and simplified controls.

Champion and Johnson have added clutches that disengage the propeller in the 4- to 7-hp models. Scott-Atwater uses a three-speed shift, a separate fuel tank and a steering wheel control for both throttle and spark.

The 25-hp mercury Thunderbolt, weighing only 122 lb has a special

connecting rod construction that permits increased crankshaft speeds. Neptune features a neutral clutch and a swing-away shroud that eases adjustment and spark-plug changing.

Flambeau introduced a new 6-hp unit with a single adjustment for controlling fuel mixtures in both manifolds of their down-draught dual carburetor. Martin's 10-hp Commando has a non-flooding carburetor.

## McGraw Educational Award Nominations Still Open

THE JAMES H. MCGRAW AWARD in Technical Institute Education will be presented for the first time at the Seattle meeting of the American Society for Engineering Education in June on the University of Washington campus.

Sponsored by the McGraw-Hill Book Company in memory of James H. McGraw, Sr., founder of the company, the $500 prize is given for the purpose of recognizing and encouraging oustanding contributions to technical institute education in the United States.

Thorndike Saville, Dean of Engineering at New York University and Society for Engineering Education, has appointed a committee of distinguished educators to select the recipient of the award for 1950. The committee will consider contributions that lie within the three categories of teaching, publication, or administration. It is not expected that nominees for the Award shall be outstanding in all three categories.

Nomination forms can be obtained from A. B. Bronwell, Northwestern University, Evanston, Illinois. Nominations can be made by any person or persons other than members of the Award Committee, or employees of the McGraw-Hill Companies. Nominations for recipients of the Award for 1950 must be mailed or delivered by March 15, 1950, to Chairman H. P. Rodes, James H. McGraw Award Committee, 130 Administration Building, University of California, Los Angeles 24, California.

## Die Casting Institute Establishes Annual Award

WITH A DONATION by the Doehler-Jarvis Corporation of $25,000 as a perpetual trust fund, the American Die Casting Institute is inaugurating this year the first annual Doehler award. Carrying with it a $500 honorarium, the prize will be made annually for the outstanding contribution to the advancement of the die casting industry or to the art of die casting.

The Award Committee consists of the Institute's Board of Directors who will determine the winner each year. Any individual or group either within or outside the die casting industry is eligible.

Nominations for the Award and supporting papers or other material will be received annually from January 1 to April 30. Entries should be addressed to: Award Committee, American Die Casting Institute, 366 Madison Avenue, New York 17, N.Y.

## Simulator "Flies" Plane Before It Is Built

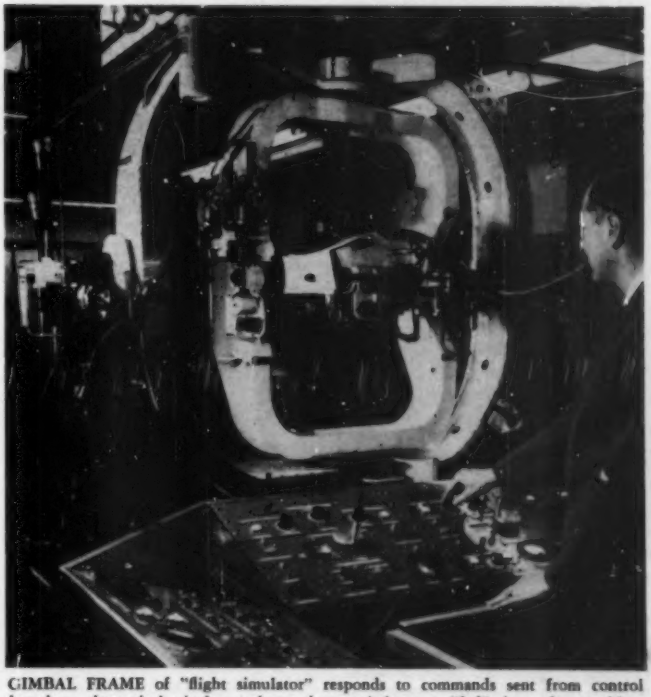
ANOTHER CALCULATING MACHINE, this one designed to "flight test" a new airplane before it is constructed, has been built by engineers at the Massachusetts Institute of Technology. With this "flight simulator", test engineers are able to set up an invisible, electrical "model" of any aircraft or guided missile in an advanced stage of design, and then apply an autopilot to "fly" the theoretical craft.

"The fundamental purpose of this machine is to permit the development of high-speed aircraft with a reduction in the time, expense and number of conventional flight tests", says Dr. Albert C. Hall, director of the M.I.T. Dynamic Analysis and Control Laboratory, in which the simulator was built.

The simulator consists of intricate computing machines and a "flight table" on which actual problems relating to flight stability are worked out. The table is an arrangement of independently-supported gimbals, delicately suspended so that they can incline freely in any direction.

The gimbal frame, operated by high-speed hydraulic servo mechanisms that automatically control instruments for carrying out motions in accordance with electrically-transmitted commands, is used to orient the automatic control system of a plane or missile just as it would be tested in actual flight. The gimbal frame table rolls, pitches and goes through all the motions the plane would make in the air under stated conditions.

Before the simulator can be used, many of the plane's characteristics—weight, velocity, altitude, wing span and many others—must be obtained from wind tunnel tests of small models of the proposed aircraft. A prob-



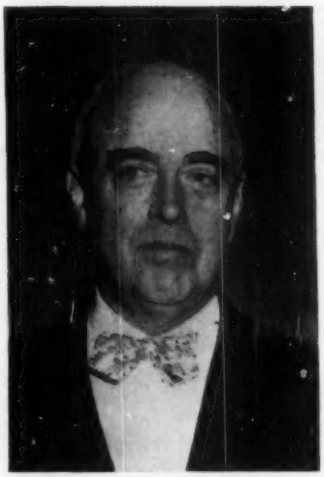
**GIMBAL FRAME** of "flight simulator" responds to commands sent from control board to theoretical airplane whose characteristics are "fed" into the machine.

lem is worked out on the apparatus by setting electronic computer dials that represent these characteristics. The answer is returned on a chart in special recording apparatus in a matter of a few seconds.

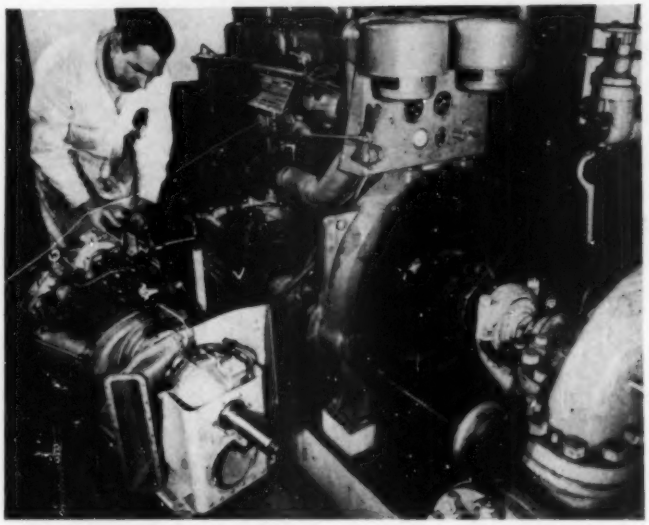
## Cost-Cutting Exposition Attracting Broad Interest

THE PRIMARY PURPOSE of the Industrial Exposition on Cost-Cutting to be staged April 10-14 by the American Society of Tool Engineers is to promote the exchange of information regarding new ideas, methods and equipment among industrial companies, both large and small. According to R. B. Douglas, president of the Society, it is a shortage of technically-trained sales engineers that has retarded the spread of this information that can contribute significantly toward cutting manufacturing costs.

Industry seems to be going for the idea as upwards of 250 companies have reserved space in Philadelphia's Convention Hall three months in advance. Information regarding the show can be obtained from Denham and Company, 812 Book Building, Detroit 26, Michigan.



**PLASTICS ENGINEERS have chosen C. Todd Clark to head the SPE during the coming year. Succeeding M. J. Petretti as president, Mr. Clark is director of the Plastics Division of the F. Burkart Manufacturing Company, St. Louis, Missouri, and is a recognized authority on plastics products containing hard fiber fillers.**



**BOEING GAS TURBINE at left requires one-fourth the space needed for industrial engine at right. Both units develop 160 hp, yet smaller weighs only 185 pounds.**

## Compact Gas Turbine Ready To Be Marketed

DEVELOPMENT OF A SMALL GAS TURBINE that will have practical value in applications outside the aircraft field has been carried to the advanced stages by engineers of the Boeing Aircraft Company. Edward C. Wells, vice-president of engineering, claims that the Boeing Model 502 turbine is, "so far as Boeing knows, the most advanced small gas turbine for general application in the United States."

Weighing only 185 lb, with a continuous output rating of 160 hp and an emergency rating of 200 hp, the turbine can be conveniently mounted in a small space for operation of standby pumps, generators and compressors. Unit is only 38 in. long as compared to 53.2 in. for a diesel engine of the same power, 23 in. wide as compared to 29 for a diesel and 18.5 in. high as compared to 45.2. Its 9.4 cu ft envelope contrasts with 40.5 cu ft for a 2,850-lb diesel; its 1 lb-per-horsepower compares to 6 lb per horsepower for most automotive engines.

The Boeing Model 500, which is the 502 without the gear box, shaft and turbine wheel, can be adapted as an efficient space heater that radiates 4,000,000 Btu per hour.

Another of the turbine's most interesting possibilities is in the marine field, where research shows it to be readily adaptable for powering small craft like launches and speed boats.

The Model 500 is an 111-lb turbojet with 180 lb of thrust. The turbine has two major sections: the gas producer, consisting of a single-stage centrifugal compressor, two can-type burners and an axial-flow turbine wheel; and the power section, where thrust is converted to shaft power.

With no mechanical link between the two sections, the gas-producer speed can be controlled independently of the output-shaft speed, resulting in an engine with an infinitely variable transmission. An extremely high torque can be developed on the output shaft by stalling the shaft while running the first stage at its rated speed. Power is not tied to the narrow speed range of compressor efficiency.

## Metal Powder Group To Discuss Cost Factors

THE CHIEF PROBLEMS facing metal powder producers and users are to be discussed at the Association's annual meeting, April 25 and 26, in Detroit's Book-Cadillac Hotel.

Formal talks by John Sasso, former managing editor of PRODUCT ENGINEERING, and A. J. Langhammer, of Chrysler's Amplex Division, will be concerned with the outlook for powder metallurgy and accounting methods for predicting the design and production costs peculiar to powder parts.

# Washington Notes

### Vandenberg Directive Expands Research in USAF

Placing further emphasis on the Air Force long-range research and development activities, General Vandenberg recently announced the formation of a new staff section and an additional USAF major command—The Research and Development Command.

This action places research and development activities on the same staff level as the four existing major staff sections—Comptroller, Personnel, Operations, and Materiel. It also constitutes a new command that parallels other major commands such as Air Materiel Command.

All research and development functions, presently operating under other major Air Staff sections, will be transferred over a period of time to the Research and Development Staff Section, with temporary headquarters in Washington.

Major General Gordon P. Saville, formerly the Director of Requirements at Headquarters, USAF, has been named Deputy Chief of Staff, Research and Development, and Major General David M. Schlatter, formerly senior Air Force member of the Military Liaison Committee to the Atomic Energy Commission, has been appointed Commanding General of the Research and Development Command.

### Synthetic Mica Reduces List of Strategic Materials

Mica crystals with an area of four square inches are being synthesized by scientists at the National Bureau of Standards. The seed-grown flakes have about the same properties of natural mica, but are superior in high-temperature applications.

According to Commerce Secretary Sawyer, "this discovery is of immense importance to the United States, which is the world's largest consumer of mica but which produces only enough to meet a fraction of its own requirements. During 1948 the United States imported over 10,000 tons of high-grade mica valued at more than $15,000,000. Synthetic mica production may make it possible for the United States to meet its own demands for this critical material."

The synthetic mica has four ingredients. Three of these are common materials sometimes used in making glass: quartz, magnesite and bauxite. The fourth—a fluorosilicate compound—is added because it acts as a crystallizing agent. It is this fourth ingredient that makes the synthetic material superior to natural mica in resistance to breakdown in high-temperature applications.

In producing synthetic mica, the four powdered ingredients are placed in a platinum-lined crucible and melted in an electrical furnace at a temperature of nearly 2,500 F. As the furnace cools, the mica crystals grow from a tiny seed at the bottom of the crucible. Ordinarily, the individual mica crystals form groups oriented in many different directions. For mass production, however, the mica crystals should be formed in parallel sheets. The key to this seems to be precision control of temperature within the crucible.

### Launching Rig for Missiles Duplicates Ship Motions

To perfect the technique of launching self-propelled missiles from the deck of a moving ship, engineers at the Naval Aircraft Factory have had to design and build a land-based motion platform that will duplicate the accelerations and velocities to which a ship at sea is subjected.

Since the missile's instruments and controls, which depend on gyroscopic and pendulum motions, must compensate for rolling (angular), pitching (linear) and lateral-horizontal displacements, the platform had to simulate all these movements individually or simultaneously.

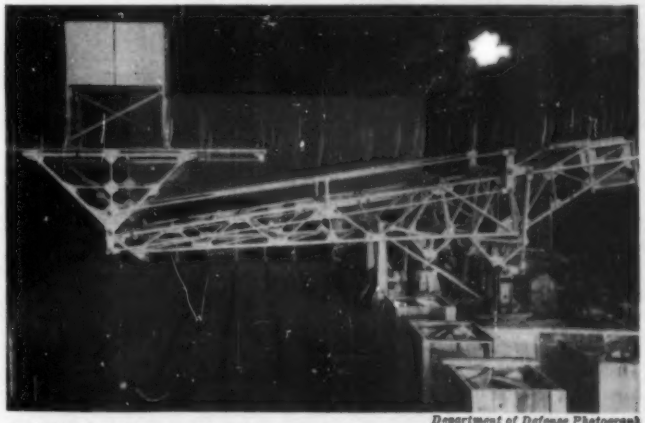
The result is the platform boom shown in the illustration. In operation, the boom resembles a 50-ft drawbridge whose outer end reciprocates vertically at a maximum speed of 6 ft per sec. Total weight of the boom, including the 1¼-ton counterweight, is 15 tons. Periodic pitching motions are smoothed out by flywheels in the drive mechanism.

To simulate pitching effects alone, the platform had to move in a straight line. This was accomplished by a Crosby steam engine indicator linkage. By applying a short-stroke, simple harmonic motion at the pitch crosshead, a similar but multiplied straight-line motion was produced at the platform itself.

The advantages of this linkage are manifold. It requires no structure above the platform that would interfere with missile takeoff; it results in an unobstructed view of the missile for study by observers and camera; and it facilitates the incorporation of a roll mechanism whose maximum weight rests on the ground and not on the boom itself.

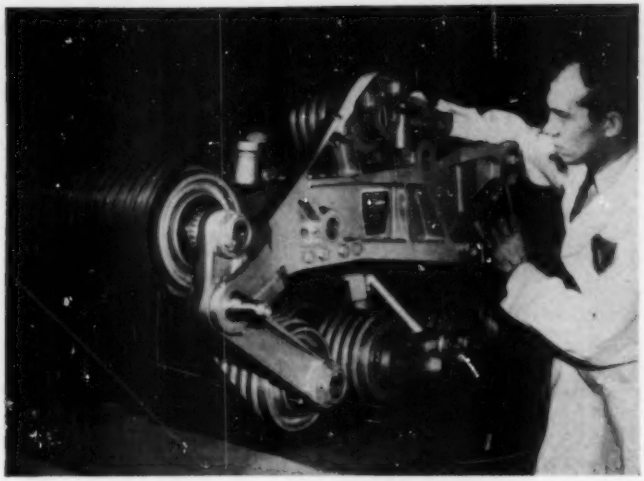
The pitch mechanism consists of a 60-hp electric motor and hydraulic pump that drive a hydraulic motor-chain unit. The chain drives a crank, connecting rod and crosshead system in which the crosshead is the actuating link of the straight-line linkage. The period of vertical motion is controlled by tilting the control plate of the hydraulic pump. The crank length is adjustable so as to vary the vertical displacement of the platform from 8 to 16 feet.

The roll motion is produced by a parallelogram linkage that extends from the platform to the ground. The linkage is driven by a crank, which is rotated through reduction gearing by a hydraulic motor. Period and ampli-



*Department of Defense Photograph*

**15-TON BOOM** for launching ship-borne missiles requires only 60 hp to reciprocate outer end at rate of 6 ft per second. Flywheels damp periodic pitching motions.



**B-50 Landing Gear Bogies Rotate at 7,000 RPM**

Flying Runway nose track gear of a B-50 bomber, largest plane yet to use the Firestone design, has withstood test landings made at 160 mph under a 30,000 lb load. Device has been proved practical in tests simulating tropic and arctic weather conditions in soft ground and sand.

The rubber track is built around steel reinforcing cables. Ribs on the inner face fit matched grooves in the forged aluminum bogie rollers to keep the belt in position when the plane makes taxi turns. Air-hydraulic springs, or oleos, maintain constant tension on the belt and serve as a shock-absorbing cushion that minimizes landing impact. Bogie rollers attain rotational speeds as high as 7,000 rpm during high-speed landings.

---

tude of roll are adjusted in the same manner as for the pitch control.

The horizontal translatory motion is produced hydraulically. Fluid in the system is forced from an actuating cylinder on the ground through flexible tubing to a second cylinder that drives the platform parallel to the cylinder. By proportioning the diameters of the two cylinders, the desired reduction in stroke is obtained.

The NAF motion platform can be used for testing many pieces of delicate apparatus used on warships.

### Thermo-Stable Ceramic Defies Physical Laws

A ceramic material, which apparently defies most accepted physical laws by contracting when heated and expanding when cooled, is being evaluated by the Air Materiel Command for possible use in radomes, jet and rocket engine parts. Formulations of the substance, called Stupalith, can be produced with linear coefficients of thermal expansion below that of any other substance. More specifically, bodies with expansion characteristics equivalent to fused silica, with zero expansion or contraction under thermal change or with pronounced thermal contraction can be made. In addition, the porosity can be varied to achieve a desired density.

The material is a processed lithium alumino-silicate capable of being formed and shaped by conventional methods of pressing, extrusion and casting. When desired, it can be machined or ground to precision tolerances. In appearance, the product is white-to-buff colored, smooth, stable, vitreous, nondevitrifying and is suitable for use in electrical and radio circuits.

Because Stupalith has exceptional strength and will withstand a thermal shock of at least 2,000 F, AMC engineers believe the new substance may find wide use in turbine blades, as well as for materials in which to house electronic instruments on airborne missiles.

Unlike most metals that conduct heat rapidly and attain uniformity of temperature quickly, most currently-used ceramics are poor thermal conductors. Pronounced temperature gradients within a body result in expansion differentials that exceed the strain point. It is the low or nonexpansion properties of the Stupalith crystal structure that lead engineers to believe the breakage of ceramics caused by sudden exposure of high or low temperatures may soon become a thing of the past.

The Stupakoff Ceramic & Manufacturing Company of Latrobe, Pa. produces this new material.

### Uniform Patent Policy For Government Patentees

An order establishing a basic policy for all government agencies on inventions made by government employees working in an official capacity has been issued by President Truman.

The directive states that the government hereafter obtains patent rights to inventions made by any government employee when the invention is (1) made during working hours; (2) made with a contribution by the government of facilities, equipment, materials, funds or information, or of time or services of other government employees on official duties; or (3) bear a direct relation to or made in consequence of the duties of the inventor.

If the government does not want the patent rights to such an invention, it can reserve authority to obtain such rights at any later time without paying royalties.

A government Patents Board to carry out the provisions of this directive was set up by the president. It consists of a chairman appointed by the president and one representative from each of the following: Departments of Agriculture, Commerce, Interior, Justice, State, Defense, Civil Service Commission, Federal Security Agency, National Advisory Committee for Aeronautics and General Services Administration.

Heretofore, government agencies have varied in their retention of patent rights to inventions of employees.

### Color Film "Variables" Reduced in USAF Processor

"Variables", long the bugaboo of all color photography, are on the way out for U. S. Air Force color transparencies. A newly-designed color processor, so completely automatic that it insures absolute uniformity of reproduction, has just gone into service in

the color unit of the Engineering Division's Photographic Laboratory at Air Materiel Command headquarters, Dayton, Ohio.

The device is a row of twelve stainless steel tanks, each holding 3½ gal of solution. Above the tanks is a row of twelve timers, and in between is a head fitted with racks to carry ten sheets of 8 by 10 in. or forty sheets of 4 by 5 in. exposed color film or reversal printing material.

The racks of film are lowered into the first tank, the solution automatically agitated for a prescribed length of time, and the rack full of film automatically lifted out and moved along a track to the next tank. Duration of immersion is controlled by pre-setting the individual timers above the tanks.

The entire process takes 90 min, but because operation is entirely automatic, laboratory employees are free to carry on other work while the film is being processed.

The 1,100-lb processor was designed and manufactured by the Newton-Niles Co. of Ann Arbor, Michigan.

## Jet Laboratory Simulates Both Speed and Altitude

A RAM JET ENGINE development laboratory that simulates flight speeds up to 2,600 mph and altitudes to 80,000 ft has recently been completed for the U. S. Air Forces by the Wright Aeronautical Corporation.

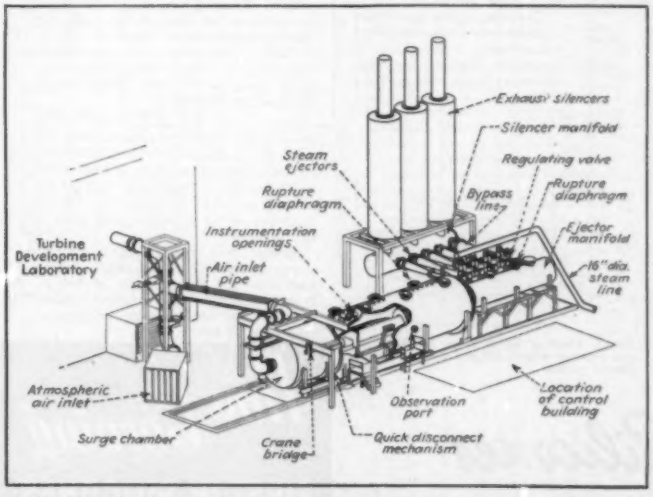
The installation represents a total investment by the Air Force of only $600,000—a fraction of the cost had not existing facilities been utilized. By using 140 tons per hour of air delivered from a turbine compressor in the adjoining Gas Turbine Development Laboratory built two years ago, and by speeding airflow with 150 tons per hour of steam from the existing boiler house, a highly effective laboratory has been built in record time.

Ram jets up to 20 inches in diameter can be operated in the central test cell, which is a steel tank 12 ft in diameter and 96 ft long. Air is pumped to this chamber from the Development Laboratory via a surge chamber that reduces turbulence. With the surge chamber separated from the end of the tank, the ram jet to be tested is mounted on a platform in the center of the test chamber. A winch then pulls the 18-ton surge chamber up to the end of the main tank. Hydraulic jacks finally seal the two flanges by forcing wedges on one flange through guide pins in the other.

Several steam jets are pointed into the exhaust system to aid or retard the escape of exhaust gas. By varying the incoming air pressure and the outlet pressure, it is possible to simulate various altitudes and speeds.

Because of the 4,000-F temperatures encountered in the exhaust system, the entire test chamber elongates as much as an inch. The unit is therefore mounted on rollers to allow for this expansion. To dampen vibration, the track that supports the rollers is mounted on twenty isolators, each containing four adjustable coil springs.

An elaborate cooling system, which jackets the chamber with a layer of circulating water, is an integral part of the tank for absorbing some of the heat generated by the engine. At certain parts of the chamber, notably near the entrance to the diffuser, the temperature of the gases reaches 3,500 F. Three sets of water jets reduce this temperature to 800 F before the gases pass into the exhaust line. Three 45-ft silencers installed at the end of the exhaust line muffle the roar of exhaust gases and steam jets.




**RAM JET TEST chamber simulates speeds of Mach 4 at 80,000 ft through use of compressed air and high-pressure steam from adjacent turbine and boiler plant.**

### RAM JET DESIGNERS HAVE MANY HEADACHES

AS DESIGNERS HAVE DELVED DEEPER into the workings of the ram-jet engine, they have become thoroughly convinced that the popular conception of a flame-shooting pipe is a misnomer.

The many design problems, aside from those concerned with materials that will stand the gaff at 3,500 F, are complex, to say the least. Instead of a fuel injector and spark plug located part way down the shell, designers have substituted a streamlined "center body" within the shell. And within a diameter less than 20 in., they have to cram many complicated mechanisms. Chief among these are: an auxiliary turbine powered by air from the main air stream, a large capacity fuel pump, a generator and a power control.

Some of the design problems of these functional units are:

- Turbine must be properly lubricated and coupled to the fuel pump and generator.
- Pump must respond quickly to changes in fuel requirements.
- Generator must provide a regulated output for ignition and power-control electrical systems.
- Power control must monitor fuel-air ratio to compensate for continuously changing speed, temperature and air density.
- Response must be in the order of 1/25 sec over a range from sea level to 80,000 feet.

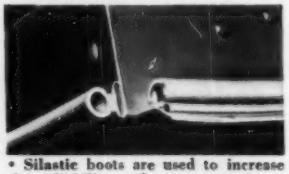
# Dow Corning Silicone News

DOW CORNING CORPORATION, MIDLAND, MICHIGAN

## SILASTIC* withstands operating conditions in Convair B-36

The Convair B-36, with a service ceiling above 40,000 feet, requires materials that withstand operating temperatures ranging from −100° to +500°F. That's why Silastic is used in so many places. For example:

• Silastic gaskets reinforced with glass cloth are used to seal the cabin heating and pressurizing systems at operating temperatures in the range of −70° to 400°F.



• Silastic boots are used to increase the reliability and to prevent corrosion and untimely shorting of the limit control switches made by Exhibit Supply Company. They retain their strength and flexibility at temperatures of −100°F.

• Silastic gaskets reinforced with glass cloth are used to seal the rocker arm housings in Pratt and Whitney Wasp Major engines. They withstand hot oil at operating temperatures in the range of 450°F.

• Silastic is used to seal bomb bay doors and the cover plates, doors and windows in camera bays, where flexibility and resilience are required at temperatures ranging from −100° to +160°F.

For more data on Silastic phone our nearest branch office or write for *New* Silastic Facts data sheet (Q-15).

### *Heat aging at 390°F. proves superiority of Silastic*

Because Dow Corning Silicones are serviceable over such a wide temperature span, we are obliged to collect data at temperatures far above and below the limits of conventional materials. In most cases there are no comparable data on the properties of organic materials.

The data given in Figure 1 shows how irrelevant room temperature values are in materials exposed to high operating temperatures. Take an organic rubber compounded to meet the requirements of AMS 3202C for heat resistant rubbers. It loses 80% of its tensile strength and 98% of its elongation after 24 hours at 390°F. It ceases to be a rubber; becomes a brittle solid.

Silastic 250 retains 56% of its strength and 38% of its initial elongation after 60 days in air at 390°F. It is the strongest and toughest rubber available for service over a temperature span of 600°F.

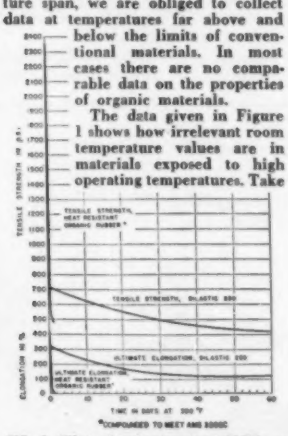
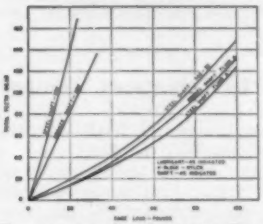

TENSILE STRENGTH, HEAT RESISTANT ORGANIC RUBBER*
TENSILE STRENGTH, SILASTIC 250
ULTIMATE ELONGATION, SILASTIC 250
ULTIMATE ELONGATION, HEAT RESISTANT ORGANIC RUBBER*
TIME IN DAYS AT 390°F
*COMPOUNDED TO MEET AMS 3202C

FIG. 1. Effect of aging in air at 390°F. on properties of Silastic 250 and a heat resistant organic rubber.

## DC 200 SILICONE FLUID

### *increases life of nylon gears and bearings*



Wear test results shown in Figure 2 indicate that DC 200 Silicone Fluid, 100 centistoke grade, is an excellent lubricant for nylon gears and bearings operating against steel or bronze under gage loads up to 100 pounds. This confirms practical experience under actual service conditions.

These same tests show that unlubricated nylon is subject to excessive wear even under light loads. DC 200 Fluid (Fluid A) appears to be superior to an SAE 30 oil as a lubricant for nylon, and it is much more permanent.

DC 200 Fluids are practically nonvolatile at temperatures as high as 200°C. (390°F.) They do not oxidize to form gums after thousands of hours at 150°C. Pour points are below −40°C. Viscosity is about 50 times as constant as that of an SAE oil over a temperature range of −25°C. to 130°C. They also show remarkable resistance to shear breakdown. For more data on DC 200 Fluids write for booklet (Q-15A).

(*T.M. Reg. U.S. Pat. Off.)


First in Silicones

ATLANTA • CHICAGO • CLEVELAND • DALLAS • LOS ANGELES • NEW YORK

In Canada: Fiberglas Canada, Ltd., Toronto • In Great Britain: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

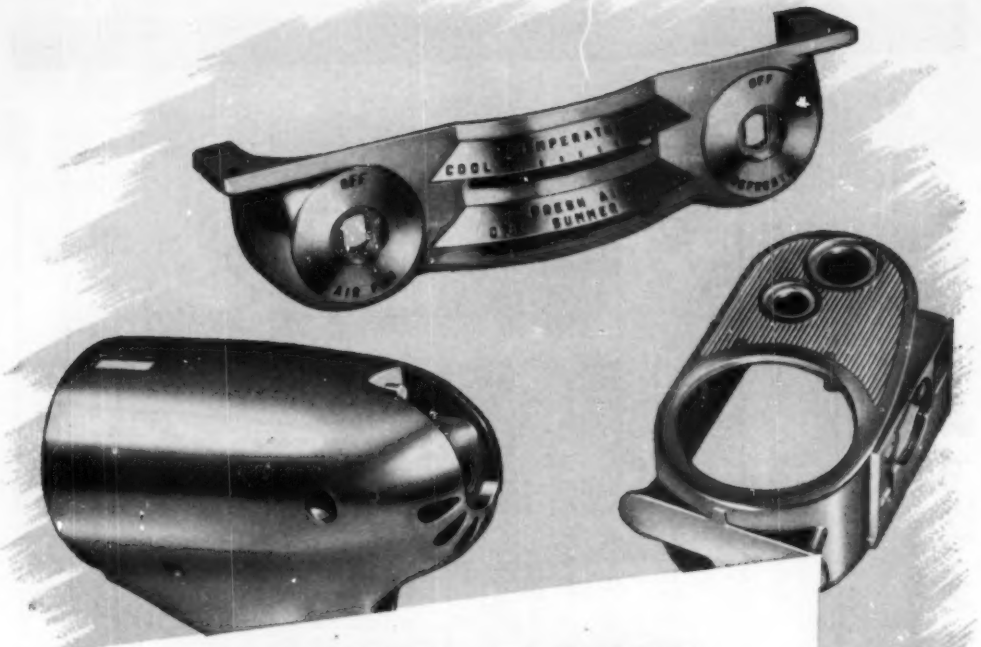
# Average Properties of Unmodified and Modified Styrene Plastics

SANFORD E. GLICK, PLASTICS DIVISION, MONSANTO CHEMICAL COMPANY

*(See article page 81)*

| Property | ASTM Method | UNMODIFIED | | MODIFIED | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | General Purpose Polystyrene (Lustrex L) | Heat Resistant Polystyrene (Lustrex LX) | Cerex 250 | P-8 | Plexene M | Plexene TA | Styron 475 | Polyglas P | X-601 Latex-Loaded Fiberglas Mat |
| Specific Gravity | D792-44T | 1.05 | 1.05 | 1.04–1.06 | 1.05–1.07 | 1.08 | 1.05 | 1.05 | 1.80 | 1.28–1.42 |
| Tensile Strength, psi | D638-44T | 6,400–7,600 | 7,000–8,000 | 7,000–10,000 | 8,500–9,500 | 9,000–10,000 | 4,700–6,100 | 4,500 | — | 6,100–11,600 |
| Elongation, percent | D638-44T | 1.5–2.2 | 1.8–2.4 | 1.5–2.5 | 1.0–2.0 | — | 25 ± 10 | 27 | — | — |
| Impact Strength, Izod, ft-lb, notched | D256-43T | 0.25–0.35 | 0.25–0.35 | 0.25–0.35 | 0.3–0.45 | 0.8–1.2 | 4.6–5.2 | 1.0 ± 0.2 | 0.46* | 2.8–5.2 |
| Flexural Strength, psi | D790-45T | 8,500–12,000 | 10,000–14,000 | 10,000–15,000 | 12,000–13,000 | 15,000–17,000 | 9,600 | 7,000 | — | 14,800–28,600 |
| Rockwell Hardness | D785-44T | M65–M80 | M65–M80 | M70–M80 | M76–M80 | M85–M95 | L65 | L75 | — | — |
| Heat Distortion Temp., F | D648-44T | 183–194 | 203–210 | 227–234 | 200–210 | 190–200 | 174–183 | 156 | 187 | — |
| Water Absorption, 24 hr, percent | D570-42 | 0.03–0.04 | 0.04–0.05 | 0.04–0.08 | 0.08 | 0.3 | 0.3 | 0.06 | 0.07 | 0.18–1.05 |
| Dielectric Constant | D150-46T | | | | | | | | | |
| 60 Cycles | | 2.45–2.65 | 2.5–2.7 | 2.55–2.65 | 2.55–2.58 | 3.5–3.2 | 4.5 | — | 3.3–3.5 | — |
| $10^6$ Cycles | | 2.45–2.65 | 2.5–2.7 | 2.55–2.65 | 2.40–2.42 | 3.4–3.1 | 4.3 | 2.50 | 3.3–3.5 | — |
| $10^8$ Cycles | | 2.45–2.65 | 2.5–2.7 | 2.55–2.65 | 2.40–2.42 | 3.1–3.0 | 3.7 | 2.48 | 3.3–3.5 | — |
| Power Factor | D150-46T | | | | | | | | | |
| 60 Cycles | | 0.0001–0.0003 | 0.0001–0.0003 | 0.0001–0.0003 | 0.0001–0.0002 | 0.001–0.002 | 0.015 | — | 0.0005–0.0015 | — |
| $10^6$ Cycles | | 0.0001–0.0003 | 0.0001–0.0003 | 0.0001–0.0003 | 0.0001–0.0002 | 0.001–0.002 | 0.08 | 0.00027 | 0.0005–0.0015 | — |
| $10^8$ Cycles | | 0.0001–0.0005 | 0.0001–0.0005 | 0.0001–0.0005 | 0.0001–0.0002 | 0.002–0.003 | — | 0.00054 | 0.0005–0.0015 | — |
| Dielectric Strength, volts/mil | D150-46T | >400 | >400 | >400 | 590–630 | 400–600 | >400 | — | 1,050 | — |
| Flammability, in./min | D635-44 | 1.0 | 1.0 | 1.0 | 1.0 | 0.8 (1/4 in.) | 0.8 (1/4 in.) | 2.2 (1/4 in.) | — | — |
| Injection Molding temp., F | | 300–700 | 350–700 | 375–575 | 350–650 | 430–480 | — | 400–450 | 400–600 | 70–190** |
| Injection Molding Pressure | | 10,000 up | 10,000 up | 10,000 up | 10,000 up | 15,000–25,000 | — | 15,000–18,000 | 10,000 up | 410–2,000** |
| Chemical Resistance | | Excellent resistance to alkalies; attacked by strong oxidizing acids; soluble in esters, aromatics, higher alcohols and chlorinated hydrocarbons. Good resistance to weak acids and all foods. | | | | | | | | |

*Charpy, unnotched. **This material comes in sheet form and is not "molded" in conventional sense.



# AUTO-LITE

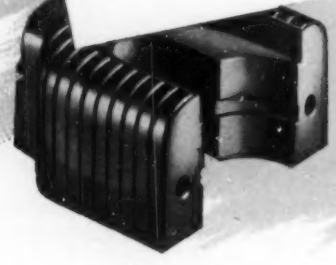
## DIE CASTINGS

● Increased production facilities for die castings made possible through the famous Auto-Lite "controlled metals" processes are now available. The opening of the great new Lockland plant of Auto-Lite, combined with the enlarged facilities at Woodstock, Illinois, greatly increases Auto-Lite's ability to furnish high quality die castings.

THE ELECTRIC AUTO-LITE COMPANY
Die Casting Division, Woodstock, Illinois

600 S. Michigan Ave.
Chicago 5, Illinois

723 New Center Bldg.
Detroit 2, Michigan

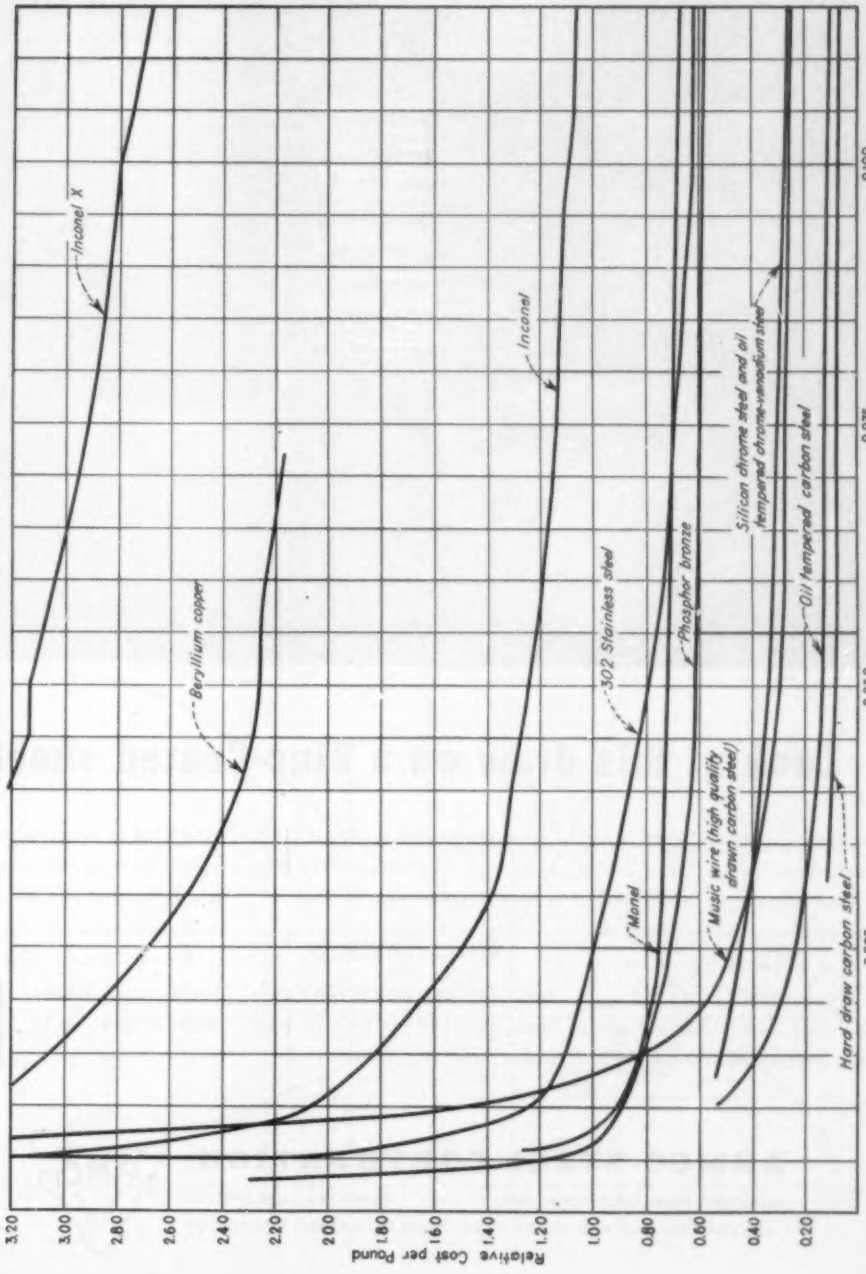


*Inquiries invited*

Catalog will be sent on request.
Write on your company letterhead.

# Approximate Relative Costs of Various Spring Materials

H. E. MACHADO, HUNTER SPRING COMPANY



# Look at this draw on a Zinc-Coated sheet!

Drawing zinc-coated steel sheets is no problem when you use Armco ZINCGRIP. The special zinc coating flows and s-t-r-e-t-c-h-e-s perfectly *with* the steel base. It doesn't flake or peel in dies or forming rolls.

How well Armco ZINCGRIP performed is illustrated by this series of draws. The finished product is 11¼" in diameter, 10½" deep—drawn from a 26⅛"-diameter circular blank.

## Shop Savings

Think of the shop savings with a mill-coated steel you can form or draw without fracturing the zinc coating! And think of the complete rust protection for your fabricated products and equipment—on sharp bends as well as flat parts.

Armco ZINCGRIP is supplied in sheets or coils. It has a record of more than 13 years in proved service.

SEE OUR CATALOG IN SWEET'S FILE

**ARMCO STEEL CORPORATION**

3650 CURTIS STREET, MIDDLETOWN, OHIO • PLANTS AND SALES OFFICES FROM COAST TO COAST • THE ARMCO INTERNATIONAL CORPORATION, WORLD-WIDE

ARMCO

# Calculating Large Deflections of Cantilever Beams

K. E. BISSHOPP
Armour Research Foundation

D. C. DRUCKER
Brown University

LARGE DEFLECTIONS OF A CANTILEVER BEAM cannot be calculated correctly from elementary beam theory. Two basic assumptions of that theory are invalid. The first of these assumptions is that the square of the slope of the beam can be neglected in the formula for the curvature. The second assumption is that the moment arm of the applied force does not shorten as the beam deflects. The inaccuracy of the elementary beam theory can be confirmed by observing that if the applied force is sufficiently large, the deflection calculated by that theory will be greater than the length of the beam.

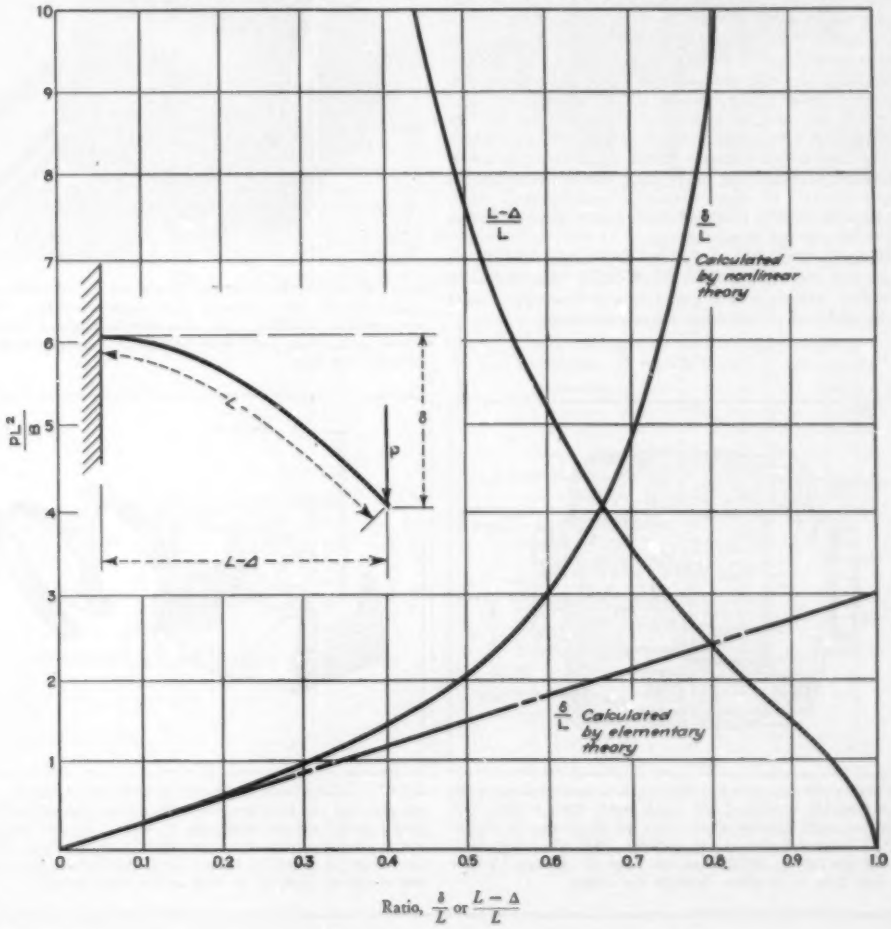
To calculate beam deflections without using these assumptions, the chart below was developed. The only assumptions made are (a) the curvature of the beam is proportional to the bending moment and (b) the overall length of the beam is not changed during bending. The curves for horizontal and vertical deflection are in good agreement with experimental results.

The following notation will be adopted:

$L$ = length of beam, in
$P$ = applied force, lb
$I$ = moment of inertia of cross-section, in.$^4$
$E$ = modulus of elasticity, psi
$\nu$ = Poisson's ratio
$\delta$ = vertical deflection, in.
$\Delta$ = horizontal deflection, in.
$B$ = flexurial rigidity.

For usual beams, $B = EI$; and, for for wide beams, $B = EI/(1 - \nu^2)$.

*Based on paper in the Quarterly of Applied Mathematics, Vol. III, No. 2, page 272 (1945).*



# New Shaded Pole Unit Bearing Motors Operate Efficiently at Any Angle

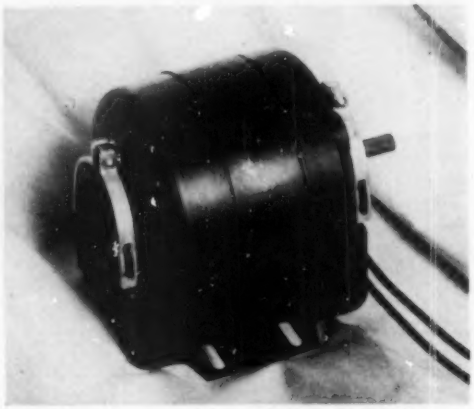
***New lubrication system and bearing design allow all-angle operation.***

Called "Type KSP", this series of shaded pole motors operates with shaft up, down, horizontal, or at any intermediate position. They come in frame sizes 11 and 21, and are for use as drives for exhaust fans, cooling fans, evaporative coolers, unit heaters, condenser cooling, and space heaters, as well as for small pumps, agitators and blowers.

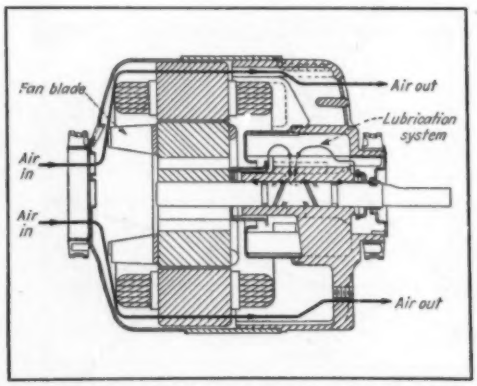
Available in either open or totally enclosed construction, they have power ratings varying from 1/40 through 1/12 hp at 115 or 230 v, 60 cycles, and at speeds from 1050 to 1550 rpm. A new lubrication and cooling system (see cut) are the chief design features. Other features include a new unit-bearing construction in the shaft end of the motor for greater strength on direct-connected loads; treated stator windings of Formex insulated wire; and resilient end rings which are resistant to oil and aging.

Mounting arrangements for the new motors include resilient end ring mounting, resilient cradle base, and band mounting. Motors are also available with four tapped holes on the shaft end of the motor for end mounting.

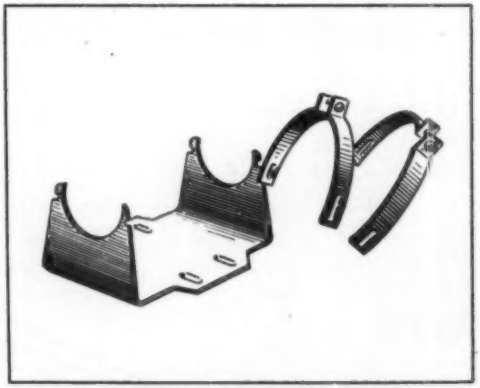
*General Electric Co., Schenectady 5, N. Y.*



**UNIT-BEARING MOTOR** can be adapted for adjustable speed operation with the application of a simple controller. Motors are available in either open or totally enclosed construction. Power ratings vary from 1/40 through 1/12 hp, at speeds from 1050 to 1550 rpm.




**ALL OIL IS** in saturated felt wicking. It is carried through the bearing post by a piece of felt which makes contact with shaft. Shaft has spiral grooves which carry oil to slingers at end of shaft. Slingers return oil to wicking. All oil is circulated through the felt by capillary action. The oil is filtered by the felt each time it circulates through the system.



**MOUNTINGS AVAILABLE** include resilient cradle-base, resilient end-ring, and band mounting. Motors are also available with four tapped holes on shaft end of motor. A new lubrication and air cooling design permit mounting in any position. Motors can be used as drives for exhaust fans, cooling fans, unit heaters, and condenser cooling, as well as for small pumps.

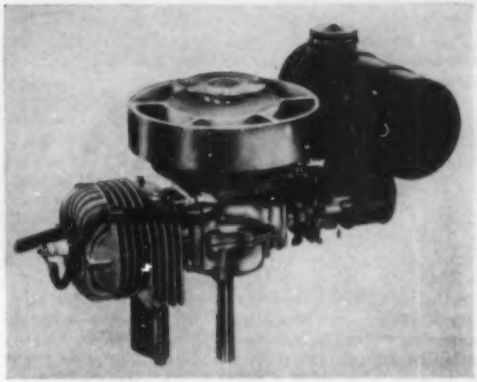
# Lightweight Gasoline Engine Has Vertical Drive

***Weighing only 14 pounds, this verticular drive gasoline engine develops one full horsepower, measured with muffler attached.***

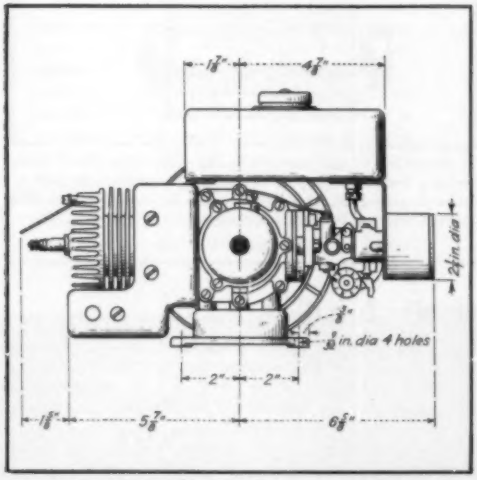
Called Model 200, this small two-cycle engine has a forged steel crank-shaft, and a regular carburetor (not a mixing valve). Most of the parts are of aluminum die castings or are permanent mold castings. The gas tank is of heavy steel. These engines are equipped with dry type air filters and standard mufflers. Governors are set at 3,300 rpm for full load operation, unless otherwise specified. Mounting flanges and stub shafts extensions are available as accessories.

Another type, Model 100, is the horizontal Counterpart of the vertical engine. It has the same specifications and performance characteristics, but has a horizontal drive. Engine modifications within the normal limitations of design will be made for each type of engine at specific customer's requests and for production quantities.

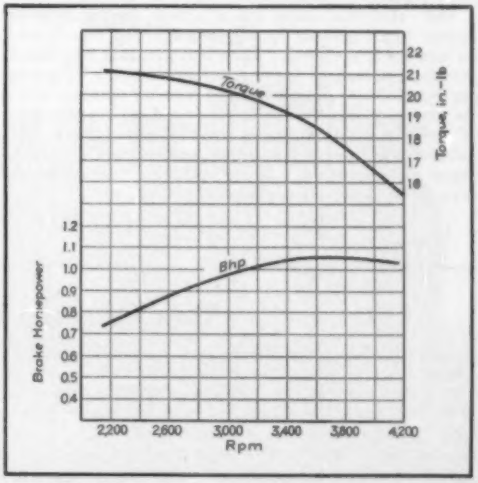
*Power Products Corp., Grafton, Wis.*



**DEVELOPING** one horsepower, this Model 200 two-cycle engine weighs only 14 lb. A variety of mountings are available for original equipment applications. The engine has a regular carburetor, and precision ball bearings.




**ALSO AVAILABLE,** this Model 100 engine has the same performance characteristics, but has a horizontal drive. A variety of mounting bases are available for the original equipment manufacturer. Engines come complete with governor.




**CURVES SHOW** performance characteristics with the muffler attached, and indicate power delivered under actual operating conditions. The engine has a 1⅛ in. bore and a 1½ in. stroke. Both the vertical and horizontal engines have similar characteristics.

CONTINUED ON PAGE 166

# Operating Valve Gives Absolute Control of Air Power

*This precise control opens new fields of use for air power. Precision machining gives the necessary seal without the use of packing.*

Performing the same function of any other operating valve, the "Hi Cyclic" valve also has these unique operating features: it will control the stroke of an air cylinder within 0.001 of an inch; stop and return the stroke at any point without over travel; control the speed of stroke in either direction.

There are no seals or packing of any type used in the valve. Precision machining to close tolerances form the necessary seals. Corrosion resistant materials are used throughout.

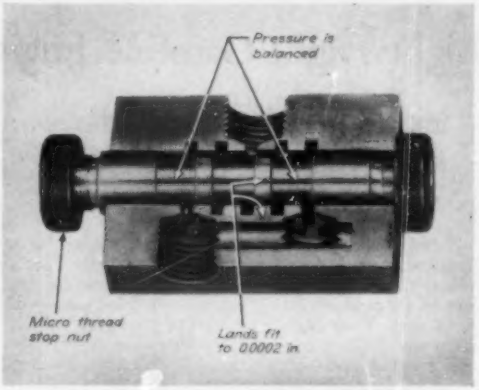
Intake air flows to both ends of the piston through dual pressure ports, equalizing the pressure on the piston and providing balanced operation. The valve operates on a slight by-pass of lubricated air, which floats the piston, making possible extremely fast, effortless operation with no lag time.

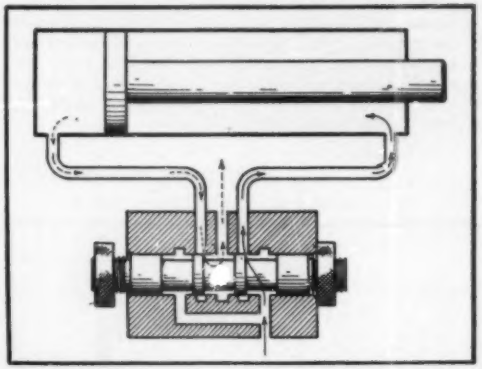
When working on a continuous or reciprocating operation, the valve requires a very small movement of the valve piston to bring about a reversal of direction to the cylinder piston. Only a small amount of air is exhausted and a corresponding amount of pressure air admitted to complete the reciprocating cycle. As the work load increases, the intake and exhaust of air will increase. Thus the consumption of air on a continuous movement is in direct ratio to the work being done, resulting in a saving in air.

The valve operates on air line pressure as low as 1 psi or as high as can be delivered to it. However, the normal passage of air passing the closed lands which is less than 2 litres per minute at 100 psi, would increase in proportion to the increased pressure. This may be objectionable on some holding operations at pressures over 150 psi.

The "Hi-Cyclic" valve has a built-in directional speed control which operates by adjusting the stop nuts located on each end of the piston. These stop nuts have micrometer threads; one turn of the stop nut equals 0.025. Turning one nut clockwise reduces the port chamber opening, limits the passage of intake and exhaust air and reduces the speed of stroke in that direction. Closure of these lands can be affected to any degree, providing positive speed control in either stroke direction. At all working speeds maximum smoothness of air cylinder operation is obtained.

*Beckett-Harcum Co., Wayne Rd., Wilmington, Ohio*



**TURNING ONE micrometer stop nut reduces the port chamber opening, limits the passage of intake and exhaust air, and reduces the speed of the cylinder stroke in that direction. The return stroke may be made at full speed.**

## Shaft Coupling Is Easily Installed

An adaptation of the "Magic-Grip" sheave principle, the "Magic-Grip" coupling consists primarily of two cast iron disks with tapered bores, rubber covered tubes assembled on studs, split tapered bushings, and two set screws for each disk. Interchangeable with old standard coupling, the new one, for the present, is available in two bore sizes—$\frac{7}{8}$ and $2\frac{1}{8}$ in. both taking up to 120 hp at 3,550 rpm. Other sizes will be added later.

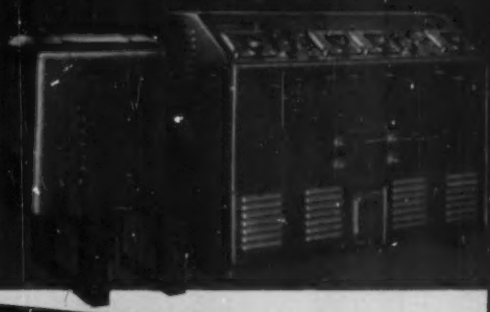
To install, the bushing is placed on the pump or motor shaft. Since it is split part way, it slides easily. The coupling is then placed over the bushing and the two set screws inserted into the "on" position holes. Then the screws are alternately tightened until they engage the recesses in the bushing. A key between the bushing and the coupling for driving the combination and lining up the correct "off" and "on" positions of both coupling and bushing makes mistaken placement impossible.

The set screws are tightened until the bushing is fastened on the shaft and the coupling and bushing tapers are firmly set.

*Allis-Chalmers Mfg. Co., Milwaukee, Wis.*

CONTINUED ON PAGE 168

Power Unit with cabinet removed; valves are gasket mounted to simplify installation, save space, improve machine appearance.



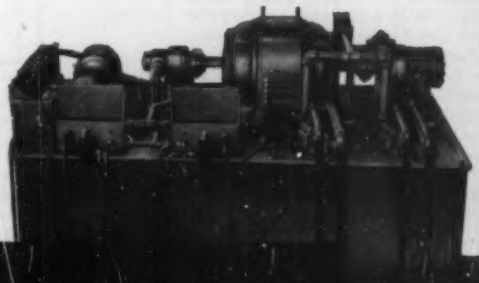
Power Unit having pump driven by standby gasoline engine.

# VICKERS Hydraulic POWER UNITS *Custom Built*

**Illustrated here are representative examples of the infinite variety of self-contained hydraulic power Units that are designed and built by Vickers for the more efficient operation of many kinds of machinery. These compact Units include all necessary pumps, valves, intermediate piping, reservoir, hydraulic accessories, motors and controls. Hydraulic connections to the machine are grouped in a convenient manifold.**

**Design is simplified because arrangement is not limited by structure of machine. Installation time and cost are substantially reduced because all hydraulic equipment is received as a self-contained "package" instead of separate parts that must be individually installed. Every Unit is pretested at factory and is ready for immediate operation. Cabinets which are optional, blend well with modern machine design. Operating adjustments and maintenance are simplified by convenient layout and gasket mounted valves. Vickers Custom Built Power Units have other important advantages . . . ask for Bulletins 47-45 and 46-43.**

- **Simplify Design**
- **Reduce Installation Costs**
- **Improve Appearance**
- **Save Time**
- **Easier Maintenance**

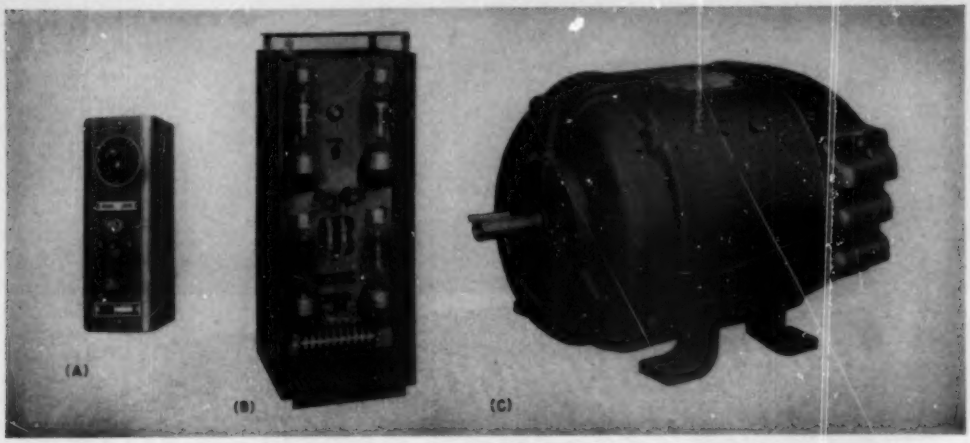


Power Unit is placed in base of machine . . . console control where convenient to operator.

**VICKERS**
**Incorporated**
*DIVISION OF THE SPERRY CORP.*

*ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921*

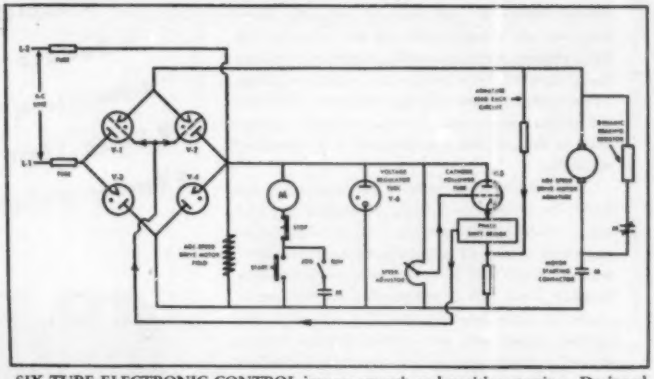
*Application Engineering Offices:* ATLANTA • CHICAGO • CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES (Metropolitan) • MILWAUKEE • NEW YORK (Metropolitan) • PHILADELPHIA • PITTSBURGH • ROCHESTER • ROCKFORD • ST. LOUIS • SEATTLE • TULSA • WASHINGTON • WORCESTER




OPERATOR'S CONTROL station (A) can be placed in most convenient position, with "start-stop" pushbuttons. "Jog" selector switch and a speed adjustment are provided. Simple electronic control unit (B) smoothly regulates speed from 290 to 2,300 rpm continuously and does not require attention. It is suitable for wall mounting. Motor (C) is rated at ¼, 1, 1½ or 2 hp and is supplied with ball-bearings in a drip proof, enclosed, fan-cooled or explosion-proof housing.

# Drive Has Three Components

This packaged, all-electric, adjustable-speed drive is available in a new, smaller size. It embodies basic principles utilized in larger drives and should fill an existing need in original equipment for a more flexible motor drive. With a minimum speed of 290 rpm for 24 hour service, this drive can operate at 80 rpm for short periods or at light load. Lower speeds are possible using a gear-motor. The overall size of the 2 hp motor is 19¾ in. long and 10⅞ in. high. Jogging for set-up work is a regular feature accomplished by use of the simple "Run-Jog" selector switch. Smooth, fast reversing is also possible.



SIX TUBE ELECTRONIC CONTROL insures smooth and positive starting. Designed to operate on single-phase ac current of from 110 to 550 volts. This circuit embodies the fundamental principles of voltage control and assures constant speed during changes in load. Rapid stops are possible with the inclusion of dynamic braking.

*Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland 10, Ohio*

# Flexible Metal Tubing Is Abrasion Resistant

This "Abrasion-Resistant" flexible tubing is designed specifically for conveying grain, rough forage, slag, insulation and other granular materials. The flexible tubing, fabricated from galvanized steel strip, is of the "fully interlocked" type, incorporating in its construction a galvanized steel strip inner liner as an integral part of the tube. The liner laps over the spaces between the tube convolutions giving a smoother inner surface. The liner also gives protection to the surface of the convolutions. The abrasion-resistant feature of the flexible tube reduces friction and allows free smooth flow of material being conveyed, with a minimum of clogging and work stoppage. Excessive wear of convoluted joints is eliminated, thereby lengthening tube life.

*Chicago Metal Hose Corp., 1302 S. Third Ave., Maywood, Ill.*

CONTINUED ON PAGE 170

# From wave to waltz...

via

R/M

FIRST IN FRICTION

*Friction materials* in the radio industry? Of course! A sintered metal, specially developed by R/M, is now used in radio controls to speed the selection of wave lengths. In addition . . . as in so many other industries . . . R/M materials are widely used by radio manufacturers in the machining, storage, and transportation of their products. For practical solutions to new problems in brake linings and clutch facings, look to R/M . . . world's largest producer of friction materials!

## RAYBESTOS-MANHATTAN, INC.

**EQUIPMENT SALES DIVISION** 620 Fisher Bldg., Detroit 2, Mich.

445 Lake Shore Drive, Chicago 11, Ill. 4651 Pacific Blvd., Los Angeles 11, Calif.

1071 Union Commerce Bldg., Cleveland 14, Ohio

Factories: Bridgeport, Conn. Manheim, Pa. Passaic, N.J. No. Charleston, S.C.

RAYBESTOS-MANHATTAN, INC., Manufacturers of Brake Linings • Brake Blocks • Clutch Facings
Fan Belts • Radiator Hose • Mechanical Rubber Products • Rubber Covered Equipment • Packings
Asbestos Textiles • Powdered Metal Products • Abrasive and Diamond Wheels • Bowling Balls

# Forged Steel Valves Are For Instrument Use

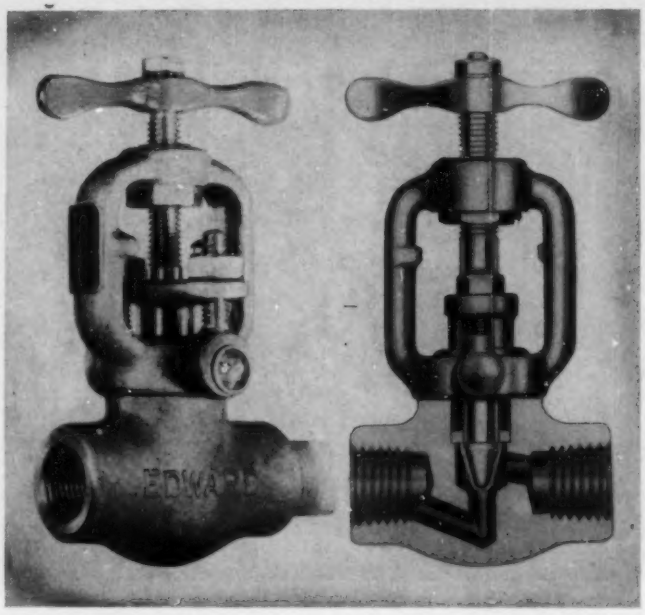
***Small stop valve fits in limited space, for working pressures of 6,000 psi.***

Featuring high working pressures, these small valves will find applications with orifice meters, regulators, instrument panels, by-pass lines, corrosive lines, and instrument installations where pressures and temperatures are high.

Ratings are from 6,000 psi at normal temperature to 1,500 psi at 1,000 deg F for the special chromium body and from 6,000 to 1,500 psi with the carbon steel body. The valve will handle steam, water, oil, and gas. Both globe and angle valves are available.

Important design features include a hard bronze yoke bushing, threaded and lock welded to the yoke; a drop forged carbon steel, heat treated yoke, and a drop forged carbon steel packing gland. The stem-disk is 13 percent chromium stainless steel, and is centerless ground for smooth packing contact. The packing is the heat-resisting die-molded type, and is treated to prevent pitting of the stem. The junk ring is stainless steel.

*Edward Valves, Inc., East Chicago, Ind.*



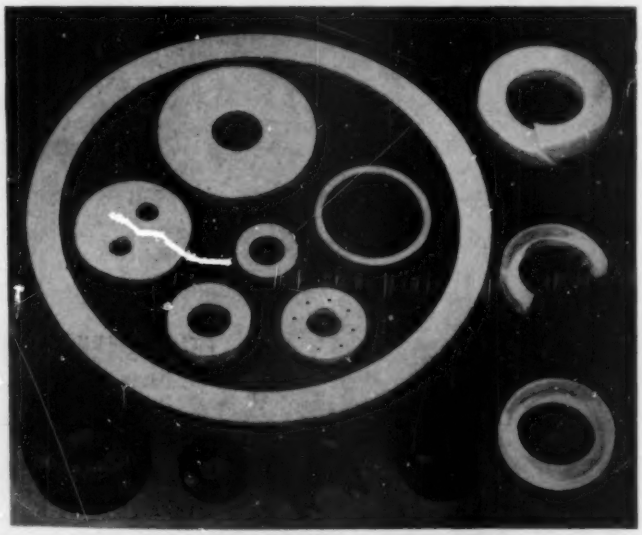
SWING BOLTED gland construction allows quick packing adjustment. The tapered needle-point stem tends to give accurate control of the flow.

# Molded Packing Is Chemically Inert

In the new molded form, "Chemlon" retains all of the chemically inert properties of "Chemlon" braided packing. It is not attacked by any acids or alkalis, and is effective to temperatures of 450 F. A new molding process results in very high flexibility. This is particularly helpful in installation of the packing rings. When split, they can be twisted and placed directly on the shaft without the necessity of removing the gland.

Another feature of "Chemlon" molded styles is the exceptional electrical properties of the material. Its combination of low power factor and low dielectric constant makes it an excellent insulator.

Among the many molded forms now furnished are washers, bushings, rings, self sealing "V" rings, ring gaskets, and jacketed gaskets.



*Crane Packing Company 1800 Cuyler Ave., Chicago, Ill.*

CONTINUED ON PAGE 172

# GOT A COUPLING PROBLEM

SHEAR PIN?
FLOATING SHAFT?
LOW SPEED?
CUT OUT?
HEAVY DUTY?
REVERSING?
HIGH SPEED?
LIGHT DUTY?

## Here's how KOPPERS Engineers *Eliminate Guesswork* when you buy couplings!

*These* FAST'S COUPLING *Services save you money!*

**UNSURPASSED ENGINEERING . . .** Koppers' engineers are acknowledged the best in the industry. Their practical knowledge, backed with 30 years' coupling experience, is at your service!

**IMMEDIATE DELIVERY . . .** All standard types and sizes are available for immediate delivery from "on hand" stocks. In case of emergency, just wire factory for special rush delivery!

**LOWEST COST PER YEAR . . .** Fast's Couplings will outlast equipment they connect if properly maintained. Their cost may be spread out over 25 years or more, offering you lowest coupling cost per year!

No matter what size couplings you need—whatever the service—*see Koppers first!* Because only Koppers offers you Fast's Couplings, *proved* the best insurance for coupling problems you can buy! For 30 years, Fast's have been industry's standard for *low-cost, trouble-free* coupling operation.

When you specify Fast's you get the benefit of Koppers Engineering service, acknowledged finest available. Koppers engineers, backed with *30 years* of Fast's Coupling experience, study your problem. Then show you *which* Fast's Coupling you need (and more important) *why you need it!*

Take advantage of Koppers long-term coupling experience. Buy Fast's Couplings and get Koppers *valuable* Engineering Service—a service you cannot buy, but which Koppers offers without obligation. The Fast's Catalog contains full details. Mail coupon for your copy today!

KOPPERS **FAST'S** THE ORIGINAL GEAR-TYPE *Couplings*

**SEND FOR FREE CATALOG**

KOPPERS CO., INC., *Fast's Coupling Dept.*,
233 Scott St., Baltimore 3, Md.

Please send me a copy of Fast's Catalog relative to.....
.....(type of industry).

Name.....
Company.....
Address.....
City..... .....Zone.....State.....

# Control Valve Regulates Interval of Fluid Flow

Called the "Water-Saver", this valve will regulate the flow of fluids at time intervals ranging from 3 seconds to 3 minutes.

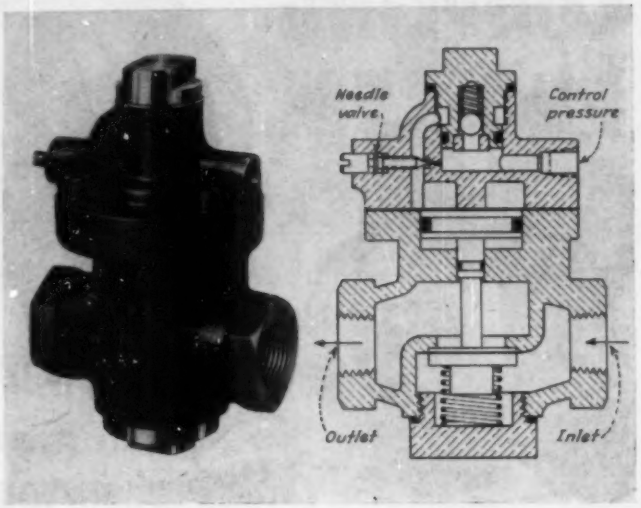
As an example of one application, an automatic screw machine with an air operated chuck could use this valve to control the flow of coolant to periods of actual operation.

The valve is hydraulically or pneumatically operated. Its flow period is set by an external control. Valves are available in pipe sizes ranging from ¼ to 1¼ in. They come in either normally open or closed types. The overall size of the largest valve is 6½ in. long, 4¾ in. wide, and 6$\frac{5}{32}$ in. high.

The interval of fluid flow is altered by the needle valve, which permits the actuating fluid to "bleed" and thus relieve the pressure on the piston. This action prevents the shock or hammer which is often associated with rapidly closing valves.

In instances where the actuating pressure is less than the fluid pressure, an adaptor can be provided.

*Ross Operating Valve Co., 120 E. Golden Gate Ave., Detroit 3, Mich.*




**CONTROL VALVE** for fluid metering is available for pipe sized from ¼ to 1¼ in. Valve will regulate flow of fluids at time intervals varying from 3 sec to 3 minutes. The section drawing illustrates simple construction. Adjustment of needle valve position in orifice alters time of valve opening.

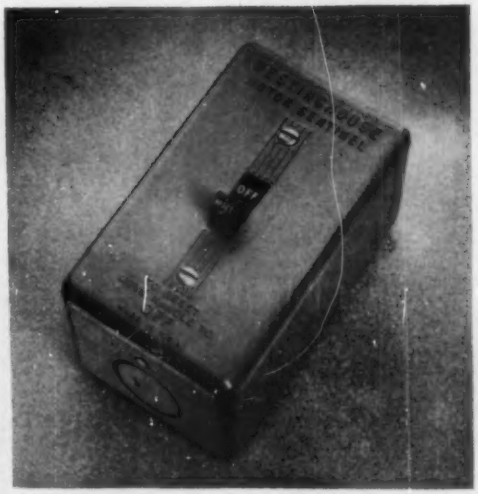
# Manual Motor Starter Permits Overload

The "Motor Sentinel" is a single or double-pole switch especially useful for protecting and controlling ac and dc fhp motors, such as those used with fans, pumps, small washing machines, and compressors. This switch has built-in positive bimetallic overload protection and with proper heater applied, permits sufficient time delay to start a small motor. It allows motors to carry overloads up to their safe capacity without disconnecting them from the line. It will, however, automatically disconnect the motor on any substained or damaging overload.

For surface mounting, the "Motor Sentinel" is available in an alloy enclosure with Bonderized baked enamel finish. Special cast iron enclosures are provided for watertight and explosion-proof applications.

Straight-through wiring avoids complicated turns and bends. For convenience and accessibility, all terminals are at the front, with line terminals at the top, and load terminals at the bottom. Maximum hp ratings range from ¼ to 1, at 115 or 230 v, ac, and 32, 125 and 250 v, dc. The starter is compact, and will fit any standard 2½ in. wall box. Several other mounting enclosures are available.

*Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.*




**STANDARD NEMA 1** enclosure is a die-cast, surface mounting, dust resistant enclosure is for general use where watertight or explosion-proof construction is not essential. Knockouts for conduit are provided at top and bottom of box.

—CONTINUED ON PAGE 174

**SANITARY... EASY TO FABRICATE**

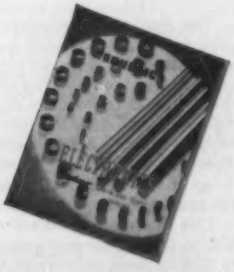
*because its*

# ELECTRUNITE

## STAINLESS STEEL TUBING

To get *all* of the benefits of Republic ENDURO Stainless Steel, plus the ease-of-fabrication which results from Republic's *exclusive* ELECTRUNITE Process of tube manufacture, always specify ELECTRUNITE Stainless Steel Tubing. You'll find out that it pays *now* as well as in the long run.

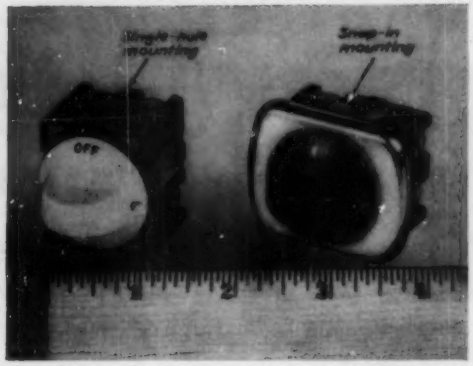
**REPUBLIC STEEL CORPORATION**
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Department: Chrysler Building, New York 17, N.Y.



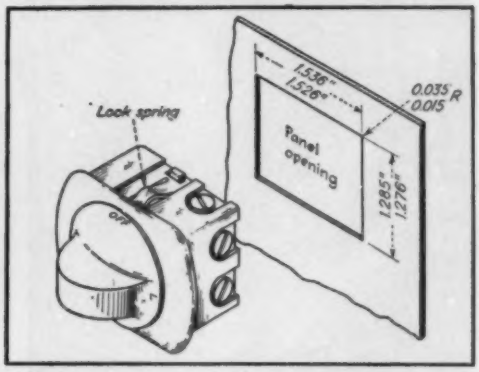
*FREE 28-page booklet gives the complete story about ELECTRUNITE Stainless Steel Tubing. Contains helpful tables, data and valuable fabricating information. Send for your copy TODAY.*

Republic REPUBLIC STEEL
ELECTRUNITE
STAINLESS STEEL TUBING

# Small Switches Operate at High Temperatures




MADE IN TWO TYPES, this small rotary switch has been designed for use with hot plates, coffee makers, and other installations where high ambient temperatures up to 400 deg F are expected. Circuits available include series parallel 3 heat, 4 position, both single and double pole; on and off, both single and double pole, and off-on, double pole.



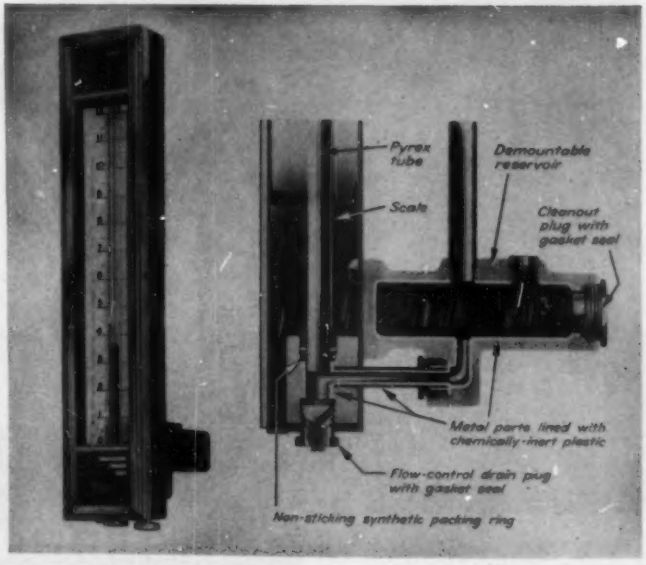

SERIES 240 switches are available in two models, one for single hole mounting, the other for snap-in mounting (above). Ratings are 15 and 7½ amps, and 125, 250 v, ac, respectively. Sizes are 1⅛ in. high, 1½ in. wide, and 1 in. deep. Switch bases are entirely enclosed with a base of heat resistant plastic. They operate on the slow-break principle to avoid shock.

*The Hart Mfg. Co., 110 Bartholomew Ave., Hartford, Conn.*

# Manometer Features Minimum Contamination

This line of reservoir-type manometers has straight-threaded and gasket-sealed drain and clean out plugs which eliminate the use of sealing compounds on all threads below the surface of the liquid. In addition, the reservoir and metal passages are lined with a thermosetting plastic to protect the liquid from contact with metal and reduce the usual frequency of cleaning.

This line of manometers are available in 14 lengths with scales from 12 to 116 in. long, for use on line pressures up to 200 psi. They can be mounted flush, flat on front of panel, on a wall, or bench mounted with a tripod. The reservoir and connecting parts are steel or brass, or stainless steel on request. They have low reservoirs, as illustrated, and raised reservoirs for measuring absolute pressure, or for measuring both pressure and vacuum. Easy cleanout is provided by a plugged opening in the rear. The reservoir is demountable for cleaning the connecting tube. A clean replacement reservoir can be installed to put the manometer back in service quickly.




*King Engineering Corp., Box 100, Ann Arbor, Mich.*

CONTINUED ON PAGE 176

# Cadillac "PLA-CHEK" insures split-tenth accuracy, solves wear problem with GRAPH-MO steel

**PLA-CHEK GAGE** *set up for checking location of holes in multiple drill-head casting.*

USED in surface plate work, this unique height gage enables measurements to be taken five to twenty times as fast as the usual method of setting up gage blocks. It gives a guaranteed accuracy of .0001" in 24 inches. Dimensions are checked from 1-inch steps on an adjustable space bar, fitted with a micrometer at the top.

To insure constant accuracy, the steel used for this long bar must possess exceptional stability. The measuring surfaces, as well as the micrometer lead screw, must resist wear in continuous service.

The Cadillac Gage Company uses Graph-Mo steel to solve both problems. Graph-Mo has outstanding stability. Due to the diamond-hard carbides in its structure, it offers stubborn resistance to wear. Yet because it contains free graphite, it machines fast and easily to precision limits. Graph-Mo hardens uniformly with minimum distortion. It gives an extremely fine finish after the grinding operation.

Graph-Mo is one of the four Timken® graphitic steels now widely used in industry for gages, dies, machine parts and many other applications. For the latest information, write for the new enlarged 9th edition of the Timken Graphitic Steel Data Book. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address "TIMROSCO".

**YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH**

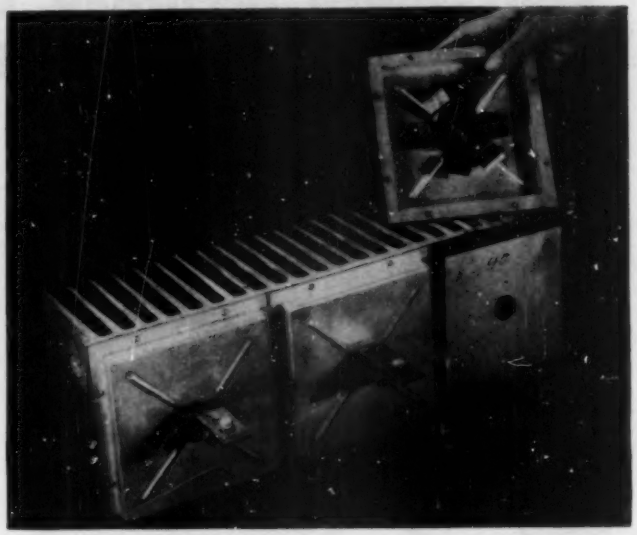
*Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.*

# Metallic Rectifier HasHighCapacity

***New arrangement of cooling fins permit higher current flow.***

New type of plate rectifier has several design features which depart from conventional construction. An aluminum casting with many vertical fins provides a large and effective cooling area as well as a means of supporting the rectifier plates. This arrangement insures optimum rectifier performance by maintaining constant plate temperatures. In addition, higher continuous operating temperatures are possible. With this greater cooling capacity, sudden surges in power can be safely transmitted without any detrimental effects to the plates.

In the conventional rectifier, the cooling fins usually consist of separate disks which are arranged in a radial manner. The integral cooling unit of the Powerector has been designed for more efficient heat transfer. The manufacturer claims that this method is so effective that the rectifier plates can satisfactorily carry much higher currents. Plate current densities of from 10 to 20 times the usual ratings are possible with this rectifier unit. As a result, a proportionately fewer number of plates are required for the same power output of a conventional metallic rectifier. Thus the weight and size of the Powerector tends to be less than that of the stack-type rectifier of comparable power output. The Powerector is available with individual cells blocking 40 v, thereby reducing the number of cells in series.



**SINGLE ALUMINUM CASTING** carries all plates of this 3 phase rectifier. A stamped cover, carrying a set of leaf spring contact fingers, protects each of the rectifier sections.

The new type of construction simplifies the problem of replacing burnt-out cells. They can be easily replaced, similar to fuses, by the operator.

This metallic rectifier, the "Powerector," is a static device with practically no maintenance requirements and is available for high kilowatt units in the medium voltage range. It can be used for various machines requiring dc power, such as: variable speed motors, arc-welding machines, magnetic chucks, relays, or brakes.

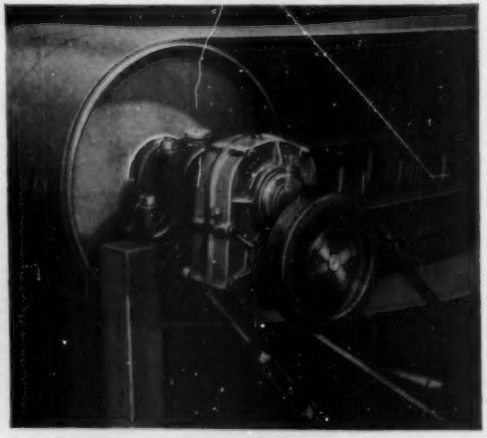
*Standard Arcturus Corp., 54 Clark St., Newark 4, N. J.*

# Speed Reducer Mounts On Driven Shaft

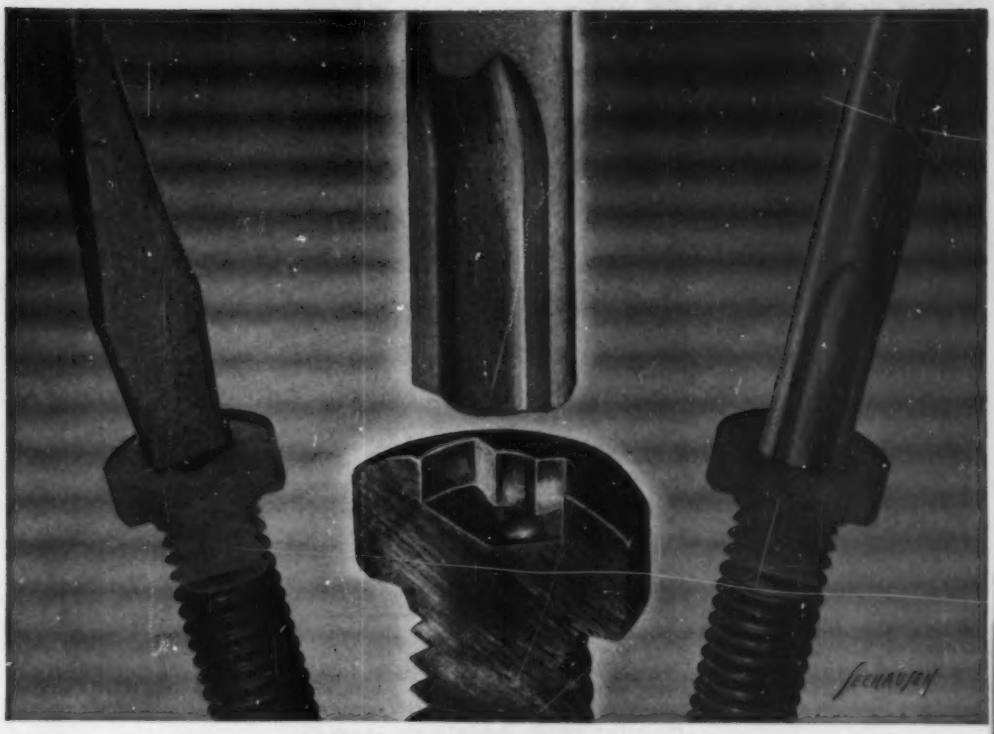
The "Torque Arm Speed Reducer" mounts directly on the shaft to be driven. It is designed as a "package" item, and is especially made to cut down on installation time. Conveyors, agitators, mixers, feeders, and processors are examples of possible applications.

The unit consists of a reducer with a fixed ratio of 15 to 1, driven by a motor through any V-belt or flat belt drive. Any desired output speed from 13 to 133 rpm can be obtained through the use of stock sheaves. The reducer contains a double train of helical steel gears, heat treated and shaved. It is locked to the shaft, on both sides of the unit, by steel locking collars. A bushing keyed into the sleeve adapts the sleeve to any desired shaft size. It is made in six sizes with capacities up to 28.5 horsepower.

*Dodge Mfg. Corp., Mishawaka, Ind.*



CONTINUED ON PAGE 178



# *Here's How* CLUTCH HEAD *Brings New Safety, New Speed in Line Assembly*

**Q.** What is the main cause of driver skidding? **A.** *"Ride-out" as set up by tapered driving.*

**Q.** How does CLUTCH HEAD overcome this "ride-out"? **A.** *By elimination of the tapered recess.*

**Q.** How does the CLUTCH HEAD engagement differ? **A.** *With straight sides of driver matching straight recess walls.*

**Q.** What safety benefit results from this engagement? **A.** *No slippage, so no damage to operators or work.*

**Q.** Does this eliminate need for end pressure? **A.** *Yes. No "ride-out" to combat; no end pressure; no skids.*

**Q.** Do CLUTCH HEAD users support this skid-free claim? **A.** *Many. Norge says "Cabinet damage eliminated."*

**Q.** What of this feature as a fatigue factor? **A.** *Effortless driving means more screws driven per day.*

**Q.** How does the Center Pivot Column add to safer driving? **A.** *It prevents canting by guiding bit into dead-center entry.*

**Q.** Why is CLUTCH HEAD "America's Most Modern Screw"? **A.** *Because it has features unmatched by any other screw.*

**Q.** What are these features?

**A.** *They include a recess engagement to match the ruggedness of the Type "A" Bit construction for driving up to 214,000 screws . . . non-stop; simple 60-second bit reconditioning; the Lock-On for easy one-handed driving, and basic design for common screwdriver operation.*

CLUTCH HEAD SCREWS

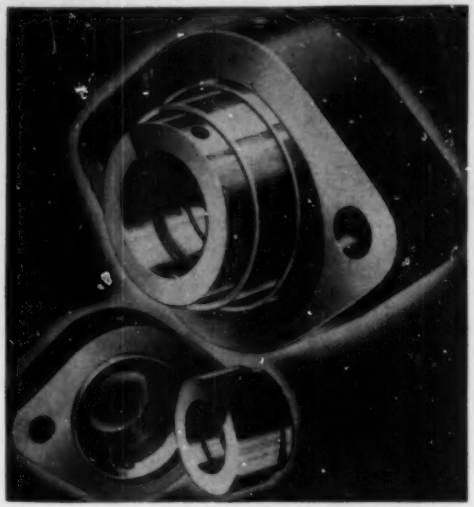
**Q.** And how may we check them?

**A.** *You may check all of these features by sending for package assortment of screws, sample Type "A" Bit, and illustrated Brochure. These will come to you by mail and will give you an understanding why CLUTCH HEAD users report 15% to 50% increases in assembly production.*

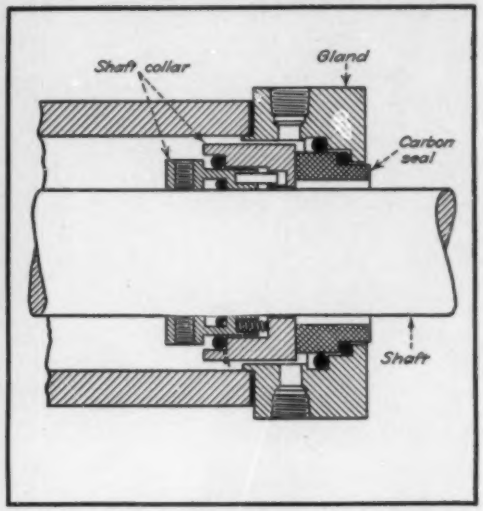
**UNITED SCREW AND BOLT CORPORATION**

CLEVELAND 2 CHICAGO 8 NEW YORK 7

# Liquid Seal Handles High Pressures and Temperatures



FEL-PRO TYPE H-P SEAL has been developed to meet the unusual sealing requirements of equipment handling hydrocarbon liquids. It is of the face-type with a full-floating feature which eliminates any shaft wear. Seal consists of two main parts: stationary gland and a rotating collar attached to the shaft.




HYDRAULIC PRESSURES are balanced which insures greater carbon-seal life due to reduced face loading. Cooling is accomplished by circulation of the liquid being handled. Assembly of this seal requires no special machining of the shaft and no adjustments are required. Maintenance costs are reduced.

*Felt Products Mfg. Co., Packing Division, Chicago, Ill.*

# New Model Transducers Are For Low Force Ranges

MODEL G7 transducer fills the need for an unbonded strain gage in the low force range. To use the instrument it is only necessary to connect 2 of its 4 electrical terminals to a power source and the other two to an indicator or recorder.

| Model | Max. Input Volts | Full Scale Open Circuit Output Millivolts | Full Scale Closed Circuit Output Microamperes | Natural Frequency cycles/second |
|---|---|---|---|---|
| G7-0.15-320 | 6 | 12 | 40 | 140 |
| G7-0.4-68 | 3 | 6 | 90 | 200 |
| G7-0.4-210 | 6 | 14 | 65 | 200 |
| G7-0.8-120 | 5 | 12 | 100 | 250 |
| G7-0.8-400 | 10 | 23 | 60 | 300 |
| G7-1.0-490 | 12 | 28 | 55 | 325 |
| G7-1.2-165 | 7 | 17 | 105 | 350 |
| G7-1.2-590 | 15 | 36 | 60 | 350 |
| G7-1.6-225 | 9 | 23 | 100 | 375 |
| G7-1.6-780 | 16 | 38 | 50 | 400 |
| G7-2.0-275 | 11 | 30 | 110 | 400 |
| G7-2.0-970 | 19 | 46 | 45 | 450 |
| G7-2.4-335 | 13 | 35 | 100 | 450 |
| G7-2.4-1150 | 23 | 56 | 50 | 475 |
| G7-3.5-445 | 16 | 45 | 100 | 525 |
| G7-4.5-550 | 19 | 53 | 95 | 600 |
| G7-5.5-600 | 20 | 58 | 90 | 625 |

CODE NUMBERS ARE: First letter and number = class of instrument; middle number = force range in ounces, plus or minus; final number = nominal bridge resistance in ohms. These specifications are pertinent: accuracy and linearity — 1 percent of full scale; resolution — 0.1 percent; breakdown voltage to ground — above 500v, rms; input current — ac or dc; temperature limit — minus 65 to plus 200 deg. F; overload characteristics — 10 percent displacement, 1 lb force.

*Stratham Laboratories, Beverly Hills, Calif.*

CONTINUED ON PAGE 180

# SYLPHON SEAL

GASES OR LIQUIDS can't seep past a Sylphon Shaft Seal. For these dependable seals hold firmly, withstand pressures up to hundreds of pounds.

## Makes rotating shafts leak-proof!

Heart of the Sylphon Shaft Seal is the Sylphon Bellows. Sylphon Seals are used in many ways—fluid transmissions, pumps, compressors, speed reducers, refrigerators, washing machines, and other units.

They seal rotating shafts gas-and-liquid-tight. Friction is reduced, power is saved. Shaft wear is minimized.

Sylphon Shaft Seals are engineered *on order*, designed for specific applications. They may be just what you need to develop or improve a product. Write for details . . . ask for Catalog EP-825. Or, ask for helpful engineering service.

TEMPERATURE CONTROLS

**FULTON SYLPHON** DIVISION Knoxville 4, Tenn.

**Robertshaw-Fulton** CONTROLS COMPANY

BELLOWS ASSEMBLIES • BELLOWS DEVICES

**BRIDGEPORT THERMOSTAT** DIVISION Bridgeport 1, Conn.

# Locknuts Have Special Nylon Locking Plug

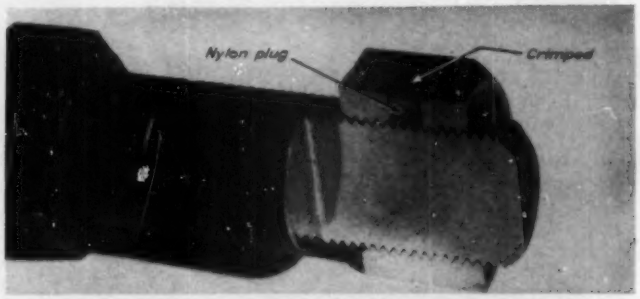
***Any standard or special nut, of almost any size, can be made into a locknut.***

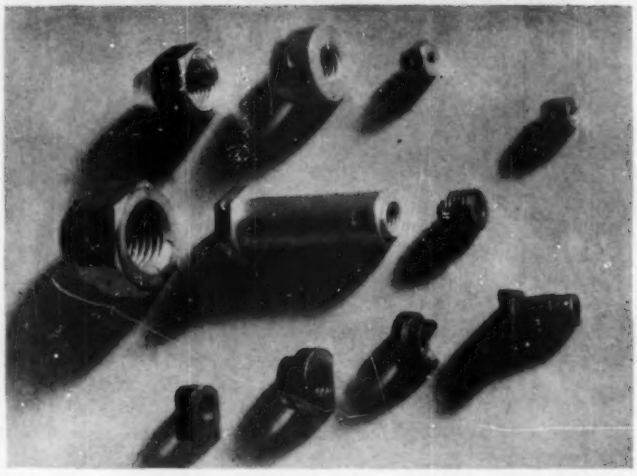
In making the "Nylock Self-Locking Nut", a cylindrical plug of nylon is forced into a round hole in one side of the nut. The top of this round hole is then crimped to retain the nylon.

When the nut is screwed on a bolt the bolt threads cut into the nylon plug. The resulting tight fit locks the nut. The natural resiliency of nylon allows the nut to be reused without loosing gripping action. A minimum wall thickness of $\frac{1}{8}$ in. and a minimum thread grip of $\frac{1}{8}$ in. are the only practical limitations in size. Where required, the nylon plug can be fixed in the bolt, or male member, rather than in the nut. Starting torque and holding torque can be controlled by the size of the plug used and the depth of crimping.

Since nylon is not affected by moisture, and most corrosive media, and does not dry out, applications are not usually limited. The nut is usually made of aluminum or steel, however, brass, bronze, or zinc can be used. The nuts can be started from either direction, just like an ordinary machine nut, and can be re-used many hundreds of times without excessive wear.

*The Nylok Corp., 475 Eighth Ave., New York 17, N. Y.*

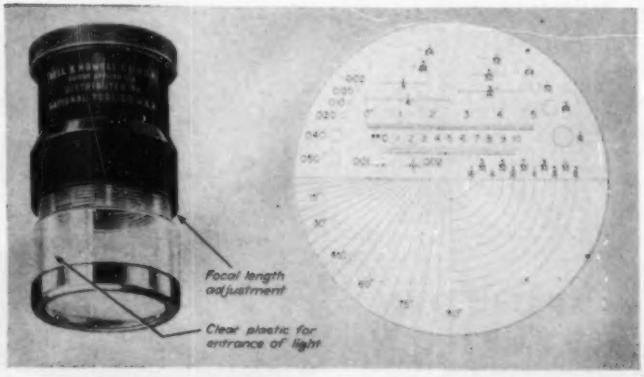


# Pocket Instrument Gives Quick Check Readings

Called the "Pocket Comparator", this small optical measuring instrument permits the user to compare the part to be checked, through a magnifying lens, against a finely calibrated recticle. The lens is a triplet-design aplanatic type and has a 7 to 1 magnification. The body of the device separates in the middle for easy cleaning and for focal length adjustment. Made primarily for production checking, the instrument will also find use in the research and development laboratory, and in the home work shop. It will be handy for spot-checking.

*National Tool Co., 11200 Madison Ave., Cleveland 2, Ohio*




CONTINUED ON PAGE 182

# FROM A SURGEON'S SUTURE...

# TO A GIANT "CAT CRACKER"...

IN A HOSPITAL OPERATING ROOM, the skillful hands of a famous surgeon deftly tie a suture made of one of metallurgy's great gifts to mankind.

It is strong, non-absorbable Republic ENDURO Stainless Steel, drawn to a thread of wire as fine as a human hair.

In a giant "cat cracker" of an oil refinery, corrosion, pressure and heat are controlled by the same miracle metal welded into huge pressure vessels.

In the 25 years since it was introduced, ENDURO has proved that there is almost no limit to its usefulness.

Its resistance to rust, corrosion and heat—its amazingly high strength—its toughness—have meant long, trouble-free life and low upkeep costs in many kinds of equipment in many industries.

Its platinum-like beauty has given sales appeal to hundreds of consumer products. From hospitals to oil refineries—from watch cases to railroad cars—Republic ENDURO Stainless Steel has earned the name of "The Thrifty Metal of 10,000 Uses."

Perhaps there is a logical place for ENDURO in your product or plant equipment. Republic engineers and metallurgists are ready to help you obtain best results.

*Distributors' stocks and competent fabricators are located in principal cities. Your local Republic representative is prepared to answer your questions.*

REPUBLIC STEEL

Enduro STAINLESS STEEL

RUST-RESISTANT • CORROSION-RESISTANT • HEAT-RESISTANT • ATTRACTIVE • SANITARY • EASY TO CLEAN
EASY TO FABRICATE • STRONG • LONG-LASTING • LOW IN END COST • What more can be desired in a material?

**REPUBLIC STEEL CORPORATION** • *Alloy Steel Division, Massillon, Ohio* • **GENERAL OFFICES, CLEVELAND 1, OHIO**

Export Department: Chrysler Building, New York 17, N. Y.

# Timing Motors Are Synchronous, Self-Starting

Made for use with time switches, range timers, coin meters, flow meters, and other such products, this new timing motor is made in Series SC (with an output shaft for one gear or pinion), and the Series LC (with an output shaft for either one pinion and one gear, or two pinions or two gears).

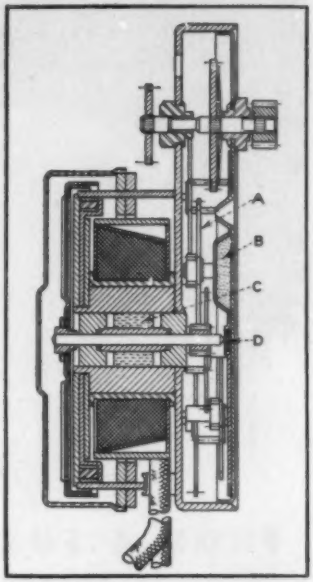
The motors have an aluminum rotor that is spoked to reduce noise and weight. All parts which come in contact with oil are treated to reduce oxidation. The motors will continue to run at constant speed from 25 percent below to 25 percent above the rated input voltage. Temperature rise at 120 v is only 36 deg F above ambient. Rotation is either clockwise or counterclockwise.

High temperature Glyptol is used to seal the gear case. This eliminates all possibility of corrosion of parts and contamination of oil, which might occur with a solder seal.

*International Register Co., 2616 W. Washington Blvd., Chicago 12, Ill.*

**OUTPUT SPEEDS** vary from 1 to 1/60 rpm. Motors operate on 120 or 240 v, ac, and at 60, 50 or 25 cycles. They can be supplied with or without a two-way clutch.

| Volts | Input Watts | Torque: Ounce-Inches at 1 RPM | |
|---|---|---|---|
| | | Starting | Running |
| 90 | 1.15 | 2.6 | 11.6 |
| 100 | 1.45 | 4.0 | 14.5 |
| 110 | 1.80 | 6.0 | 16.5 |
| 115 | 2.05 | 7.3 | 17.5 |
| 120 | 2.25 | 9.0 | 18.0 |
| 125 | 2.50 | 10.3 | 18 5 |



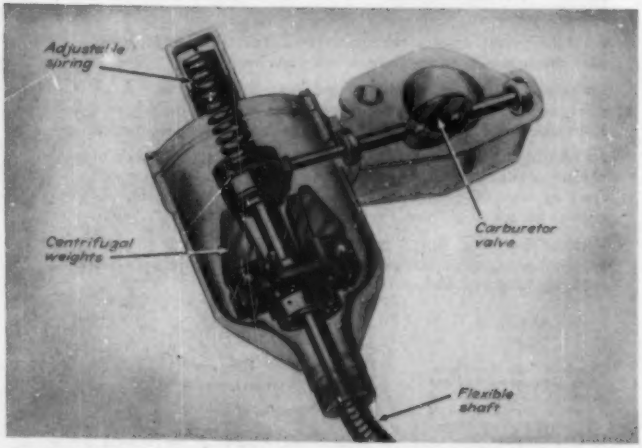

**GEAR TRAIN** is completely enclosed. Design features include: (a) a nylon gear for quiet operation; (b) felt oil reservoir; (c) a felt wick which lubricates main bearings; (d) nylon thrust bearing.

# Automotive Type Governor Has Direct Control

***Centrifugal device mounts on carburetor and driven by flexible shaft.***

This small governor can be adapted for use on various types of gasoline engines to insure operation at most efficient speed and to prevent overspeeding. It can be readily attached to the carburetor, regardless of location, because of the flexible drive cable. The cable attaches to any available power source. There is only one simple spring adjustment needed to alter the engine speed. The entire mechanism is totally enclosed and can be locked to prevent tampering. This enclosed feature eliminates the problem of dirt, water and corrosion. There are several special adaptors for driving the flexible shaft. A special distributor with a tachometer drive is available for some engine models.

*The Pierce Governor Co., Inc., Anderson, Ind.*




**DIRECT INSTALLATION** at carburetor gives accurate and constant engine control. Centrifugal force results in axial movement of shaft against spring force. This axial motion rotates carburetor valve which controls fuel flow.

CONTINUED ON PAGE 184

# OPPORTUNITIES *unlimited* for Design Ideas . . .

Many of today's outstanding uses for Van Huffel cold formed shapes and tubing were once just sparks of some design engineer's imagination. Like magic, intricate shapes that seemed impossible to produce, have been created out of the Van Huffel formula . . . a blending of expert knowledge of structural and functional uses with 47 years experience in building our own forming mills and dies, and rolling shapes and tubing.

Profiles shown here represent but a few of hundreds of shapes, formed in any length by Van Huffel . . . in hot or cold rolled steel, stainless steel, copper, brass, bronze, aluminum, zinc and other metals, in thickness up to 5/16 inch. Perhaps in Van Huffel rolled shapes and tubing an opportunity awaits you to make substantial savings in the cost of producing your product. Why not let us check the possibilities with you?

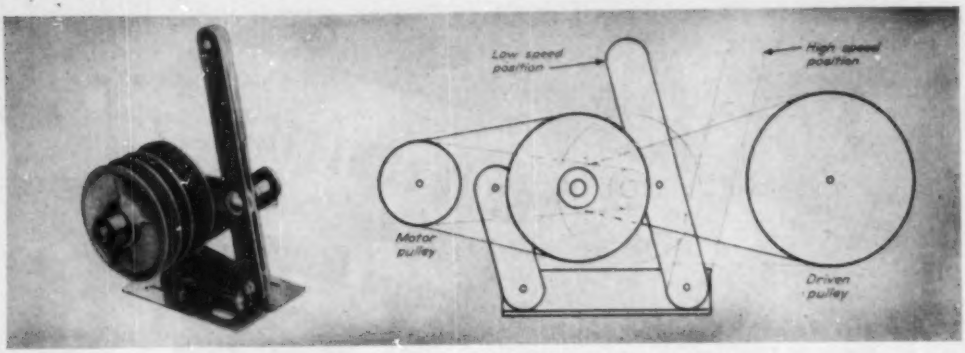
To give you an idea of the wide range and diversified application of Van Huffel Shapes and Tubing, write for illustrated brochure.

VAN HUFFEL

TUBE CORPORATION · WARREN, OHIO

*metal* SHAPES

*continuous rolled* TUBING



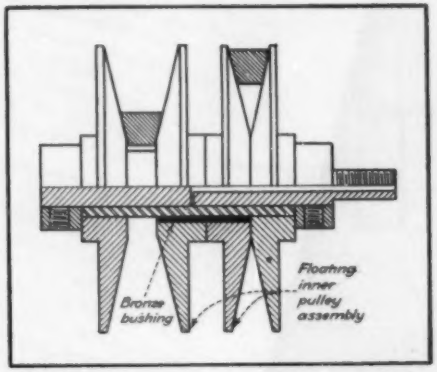

**SPEED RATIO** is controlled by the relative position of the floating inner pulley assembly. Under normal operating conditions, this inner pulley is held in equilibrium by the side forces from both V-belts. Movement of lever increases tension in one belt and at the same time decreases tension in the other. This change affects the side forces of the belt on the pulley. The belts readjust their position on the pulleys to restore equilibrium of the side forces and each belt rides on a new diameter.

# Small Variable Speed Transmission Is Die Cast

***Small size, light weight, simplicity are features.***

Made especially for the original equipment manufacturer, this light variable speed transmission is the newest and smallest of a line using the same principle of operation. The pulleys are die cast, and the frame work is stamped steel. The die cast spindle rotates on a bronze bushing over a stationary steel shaft. This shaft is anchored to the pivotal frame. The "Die Cast Cub Variable Speed Transmission" has 3.5 in. pulleys, and gives 3.3 to 1 speed range with "A" type belts. Base dimensions are 3½ by 4 inches. Overall dimensions are: width, 6 in.; length, 5½ in.; and height, 8½ in. The total weight is 5 pounds.

*Standard Transmission Equipment Co., 78 W. Union St., Pasadena 1, Calif.*




**INNER PULLEY** assembly is pinned together, and rides laterally on a bronze bushing. When one belt is forced down, the other rides up. The steel shaft is drilled for forced lubrication of moving parts.

## Sintered Metal Bearing Has Oil Reservoir

By means of a cavity of uniform size formed in the center of the bearing wall, the "Haller Oil Well Bearing" retains much more oil than conventional sintered bearings. A lubricant is forced into the sintered metal by static pressure and fills the reservoir as well as the pores of the bearing metal.

These new bearings will take heavier loads than conventional sintered bronze or sintered iron bearings because of the new lubrication feature. They are supplied in three basic types. The pocket type, which has an open cavity, is suited for particularly heavy loads. The sponge type, which has the pocket filled with sponge iron to retain the oil, is for excessive heats. Thin wall types have a group of small holes to replace the pocket so that the structure of the bearing wall is not weakened.

*Michigan Powdered Metal Products Co., Inc., Northville, Mich.*

CONTINUED ON PAGE 186

# Today it's Roebling!

## Why production men choose Roebling Cold Rolled Spring Steel

**IT'S BEEN PROVED** in plants the country over . . . that Roebling Cold Rolled Spring Steel saves preparation time on machines, minimizes machine stoppages, and cuts down the number of rejects. And this is only natural! Every inch of Roebling Spring Steel is identical in gauge, grain and finish . . . meets users' specifications with absolute uniformity.

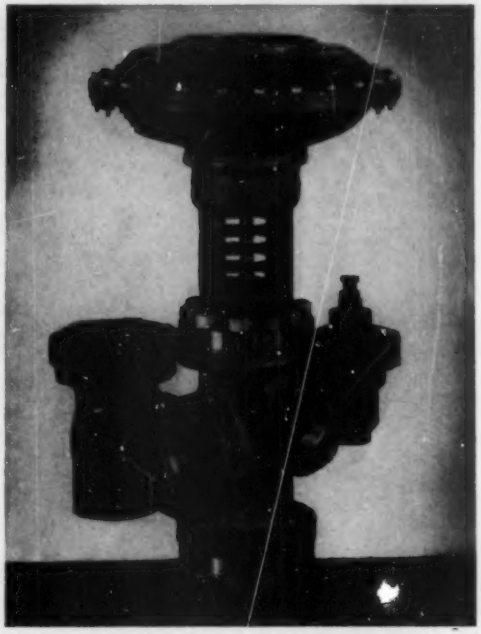
Roebling Cold Rolled Spring Steel is available annealed, hard rolled untempered; scaleless tempered; tempered and polished; tempered, polished and strawed; or tempered, polished and blued.

Your Roebling Field Man will gladly help you choose the cold rolled spring steel, or round, flat or shaped wire, that will improve your product and your production. John A. Roebling's Sons Company, Trenton 2, New Jersey.

**ROEBLING** *A CENTURY OF CONFIDENCE*

*Atlanta*, 904 Avon Ave. ★ *Boston*, 51 Sleeper St. ★ *Chicago*, 3525 W. Roosevelt Road ★ *Cincinnati*, 3253 Fredonia Ave. ★ *Cleveland*, 701 St. Clair Ave., N. E. ★ *Denver*, 4801 Jackson St. ★ *Houston*, 6216 Navigation Blvd. *Los Angeles*, 216 S. Alameda St. ★ *New York*, 19 Rector St. ★ *Philadelphia*, 12 S. Twelfth St. ★ *Portland*, 1032 N. W. 14th Ave. ★ *San Francisco*, 1740 Seventeenth St. ★ *Seattle*, 900 First Ave. S.

# Pilot Operated Valve Controls Hydraulic Cylinders



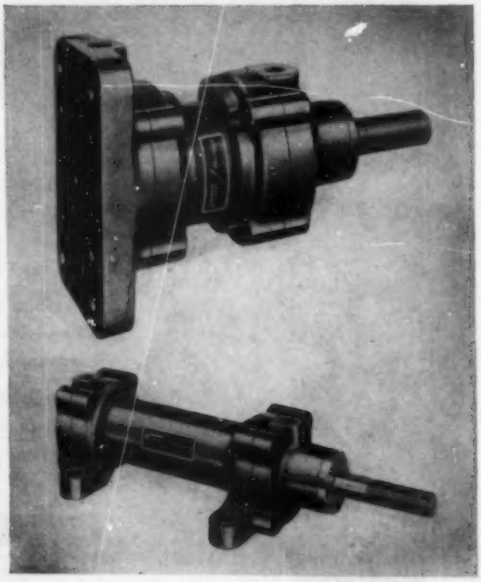
Designated "Series 805", this air pilot operated valve is used to control hydraulic cylinder operated machinery which normally operates from low pressures to produce long strokes and then uses high pressures to provide working tonnage.

Being air pilot operated, it requires little exertion to operate, and can be tied in with automatic control devices. The "Series 805" is made in 2½ to 3 in. sizes, and is composed of three units joined by nipples into one working unit. The main element is a three-way valve which may be tapped to either 2½ or 3 in. npt. One auxiliary element is a newly designed check valve having a reversible disk to give a spare seating surface. Capacity through this check valve equals that of the main three-way valve. The other auxiliary element is a high pressure inlet valve which automatically admits the small displacement of high pressure fluid required when the low pressure in the cylinder attains the preadjusted valve.

The valve is poppet type throughout, all seats and disks of hardened stainless steel. Seat rings and disks are removable for replacement. Bodies are made of heavy walled bronze castings for up to 3,500 psi service and for higher pressures they are made of stainless steel.

*Seely Instrument Co., Inc., 377 Fourth St., Niagara Falls, N. Y.*

# Stock Hydraulic Cylinder Line Has Wide Size Range



Series LA oil hydraulic cylinders are stock items with 12 standard mounting arrangements and 12 standard bores ranging from 1 to 8 inches. Any reasonable stroke length can be furnished. Any combination of stroke length, bore, and mounting arrangement can be furnished.

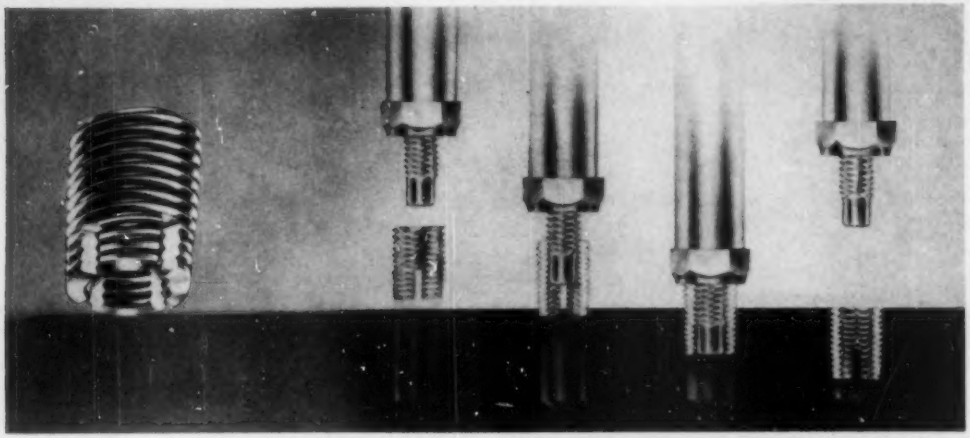
These new cylinders have been designed with improved head seals, multiple-piping connections, and self-adjusting packings. To prevent shock at the end of piston travel, integral hydraulic cushions can be provided to decelerate the piston rod movement on either or both ends of the stroke. The amount of cushioning can be controlled by a needle valve. The cylinder design conforms to the JIC Hydraulic Standards for Industrial Equipment.

Cylinders can be obtained with a heavy-duty piston rod where extra stiffness is required. This type of cylinder can be used for differential hydraulic circuits with a valving arrangement which provides a difference in speed and force on each of the piston strokes.

*Vickers Inc., 1400 Oakman Blvd., Detroit 32, Mich..*

CONTINUED ON PAGE 188

Reynolds weaves
WIRE CLOTH EXACTLY TO YOUR SPECIFICATIONS
• Yes, your product *is* different. The wire cloth you put into your product must meet its special needs. You want cloth that is different from "standard." Then write your own specifications—Reynolds will weave it accordingly. Specify the metal or alloy, as well as the diameter of the wire—temper, workability and flexibility will be *right!* Weave and mesh of the cloth, and finish, too—all exactly as ordered. Reynolds knows how—from 53 years' experience. If you want your industrial wire cloth "tailor made," send your specifications to Reynolds engineers, metallurgists and weaving experts . . . an inquiry neither costs nor obligates you.
Reynolds
Industrial
WIRE
CLOTH
REYNOLDS WIRE CO., DIXON, ILLINOIS



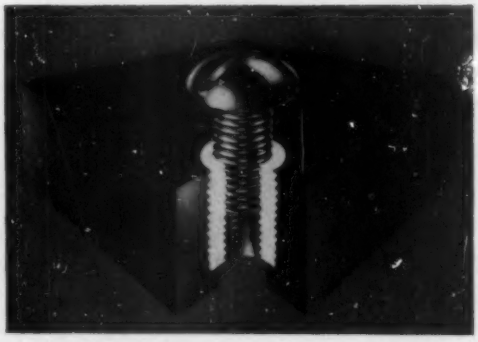
WHEN INSERTING this fastener, a clean hole is drilled equal in size to a tap drill hole for the external thread of the insert. The rotating driver engages internal threads and turns insert, which cuts its own threads with the edges of its four slotted segments. The driver is then reversed and lifted to leave the insert firmly in place and ready to receive a fastener.

# Insert Aids Fastening Of Soft Materials

Used as a permanent fastener for wood, plastics, aluminum and magnesium castings, and other materials that are machineable but of insufficient shear strength, these "Tap-Lok" inserts increase the shear area enough to allow standard machine screw or stud fastening.

They are made of steel, heat treated alloy steels, stainless steel, or brass. Tools used for insertion are either supplied by the company, or specifications are furnished for individual manufacture. The inserts are made in standard sizes for use with screws ranging in size from 4-40 to ¼-20. Special inserts may be made to suit special customer requirements.

*Groov-Pin Corp., 2017 Kerrigan Ave., Union City, N. J.*



CUT-AWAY VIEW shows a "Tap-Lok" insert firmly embedded in a low-strength material. The insert is now ready for permanent use with standard studs, machine screws, or bolts. Inserts are usually made of brass. Steel inserts are normally used with die castings, magnesium, and aluminum.

## Capacitors Withstand High Heats

Known as type P85, these small plastic-sealed paper-case tubular capacitors can be used at 212 deg F without drip and with little loss of dielectric strength. Sizes range from 0.00025 to 0.1 mfd, and 200, 400, and 600v. Special capacities can be produced on order.

The newest feature is the use of a plastic filling rather than wax. This plastic does not crystallize or melt under heat, and gives a positive seal under humid conditions. The paper section is Aerolene impregnated, and the capacitor is sealed with Duranite.

*Aerovox Corp., New Bedford, Massachusetts*

## Tracing Paper Has "Invisible" Lines

A new cross-section paper has faint blue section lines that do not reproduce when the tracing paper is used for making blue prints. The lines are sharp and clearly legible, yet too fine to register on the blue print. The paper can be used for black and white or ozalid reproductions as well as blue prints. Best results are obtained with a fast paper. The paper comes in rag resin treated vellum as well as untreated vellum. Sheets may be punched for use with three ring note books, and may be printed with a variety of headings.

*The Ogilvie Press, 691 Fulton St., Brooklyn 17, N. Y.*

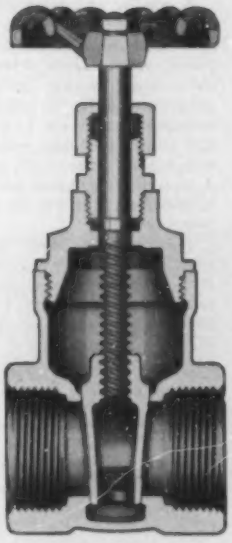
CONTINUED ON PAGE 190

# To cut piping specification time ...use the complete CRANE line

Suppose, for example, your job is to design this *Oil Preheater.* You need piping equipment ... and lots of it ... to efficiently control steam and heated fuel oil. Where can you find this equipment in a hurry? In your Crane Catalog, of course. It lists the world's most comprehensive selection of valves, fittings, pipe and accessories.

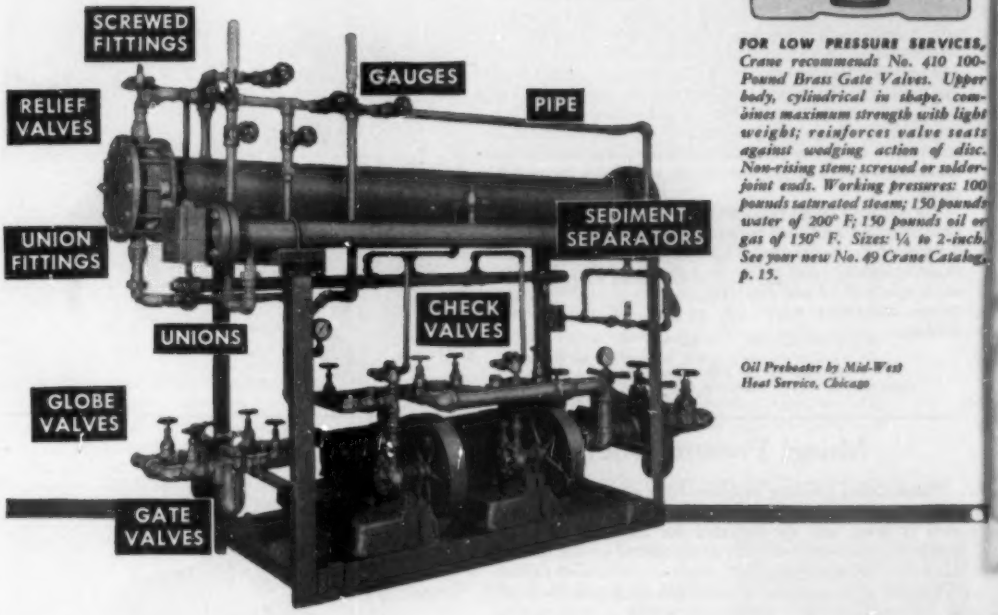
Working with Crane as your single source of supply speeds all piping procedures, from your original design through to final product assembly. Crane equipment gives your design added value, too. Machinery buyers are well aware that Crane Quality stands for the best in materials and construction of piping equipment.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
*Branches and Wholesalers Serving All Industrial Areas*



**FOR LOW PRESSURE SERVICES,** *Crane recommends No. 410 100-Pound Brass Gate Valves. Upper body, cylindrical in shape, combines maximum strength with light weight; reinforces valve seats against wedging action of disc. Non-rising stem; screwed or solder-joint ends. Working pressures: 100 pounds saturated steam; 150 pounds water of 200° F; 150 pounds oil or gas of 150° F. Sizes: ¼ to 2-inch. See your new No. 49 Crane Catalog, p. 15.*

**ALL THE PIPING EQUIPMENT YOU NEED ... ALL IN ONE COMPLETE LINE ... CRANE**




*Oil Preheater by Mid-West Heat Service, Chicago*

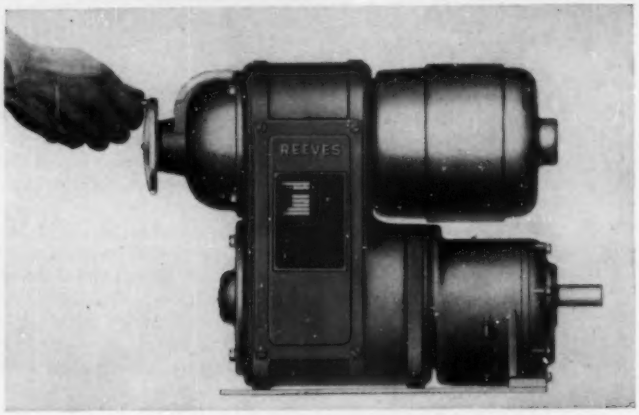
*EVERYTHING FOR EVERY PIPING SYSTEM* **CRANE**

**VALVES • FITTINGS • PIPE • PLUMBING AND HEATING**

## Variable Speed Drives Now Made in FHP Sizes

A smaller and more compact version of the Reeves "Motodrive" has been announced in fractional horsepower sizes. These drives combine motor, speed varying mechanism, and reduction gears in one unit. The new horsepower sizes are ¼, ⅓, ½, and ¾ and ratios of stepless speed variation within 10:1 are available in each size. A total of 24 different assembly combinations are available for each horsepower rating.

These new fractional "Motodrives" are designated as the "1,000 Series" and incorporate the engineering features of the larger models. With complete units as small as 9⅜ in height and 16⅞ in length, these drives will be useful where space is at a premium.

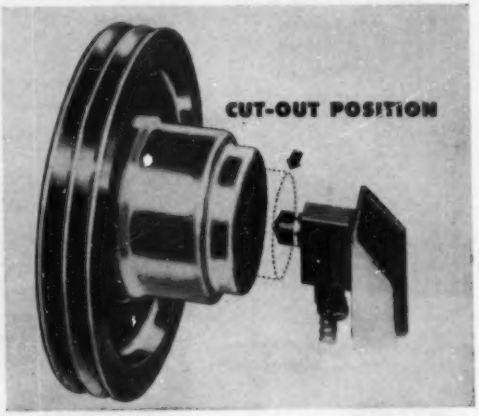



*Reeves Pulley Co., Columbus, Ind.*

## Cut-Out Protects Machine From Overload

When a machine is overloaded the "Junior Model, Size O" cut-out automatically shuts off the electric driving motor and re-sets, ready for immediate operation. The cut-out was developed to give overload protection to power drives, and replaces the usual shear pin. On machines where overloads are common, time spent in replacing sheared pins is costly and a cut-out of this kind is indispensable. With a cut-out it is only necessary to remove the cause of overload and push a button to start the machine. If the overloaded condition is not corrected, the cut-out will throw the switch again.

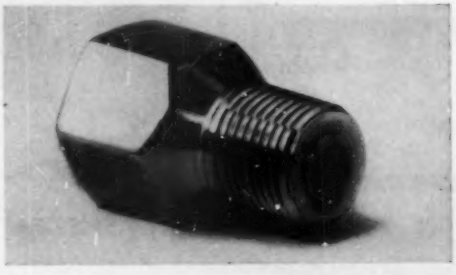
The capacity range varies from 20 to 150 in. pounds. A limit switch is furnished with the cut-out, as well as one of 4 types of drive members. Drive members can be a silent chain, sprocket, v-belt pulley, or a flat face pulley. The cut-out is splash proof and dust tight, and can be used in atmospheres containing water, oil, or acid. It can be used outdoors.




*Anchor Steel & Conveyor Co., 6906 Kingsley Ave., Dearborn, Mich.*

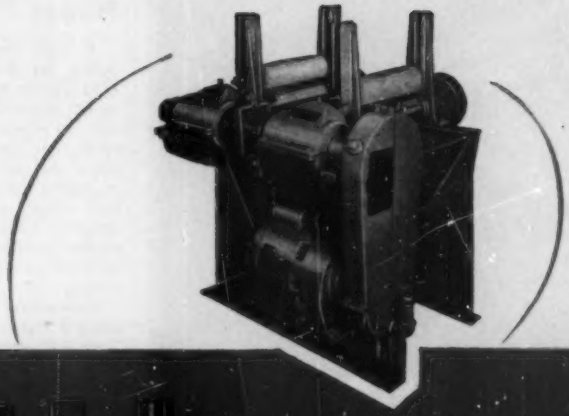
## Monel Pressure Snubbers Are Corrosion Resistant

These monel pressure snubbers have a greater corrosion resistance to certain types of liquids or gases than stainless steel or brass, and are indicated for use with all monel pressure instruments presently being offered on the market. They remove one of the chief causes of instrument failure. Where the gage is subject to continual shock and vibration, as for example, in a system containing a reciprocating pump, a steady reading of the mean pressure is obtained. Snubbers are provided in four porosities, respectively, for use with oil, water, gas and with mercury manometers.



*Chemiquip Sales Co., 195 Bradford St., Brooklyn 7, N. Y.*

CONTINUED ON PAGE 192



For nearly a half century, many power transmission problems have been presented to Carlyle Johnson engineers by builders of textile machinery. The Maxitorq floating disc Clutch seems to be well suited to this specific field . . . as is evidenced by the installation shown above.

The H. W. Butterworth & Sons Co., has selected a Maxitorq No. 22 double type as original equipment in their newest No. 657 Laboratory Jigger.

Separator Springs keep "floating discs" free in neutral . . . consequently there's no drag, no abrasion, no heating. They also assure instant, complete disengagement. Assembly, adjustment, and take-apart are manual. Clutches are shipped completely assembled, ready to slip onto a shaft.

All clutches can be supplied with Pulley Type, Cut-off Coupling, or Ring Type driving cups. Eight sizes from ¼ to 15 H.P. at 100 r.p.m., single or double, wet or dry. Clutches also available with Automatic Overload Release feature.

We'd like to have *you* join our "Good Company" users.

***Send for new 1950 Calalog PE3***

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

**. . . and it's safer, too**

Save space in mounting . . . get convenient, safe operation. Ward Leonard's new 4120 AC Combination Magnetic Starter with Disconnect Switch is *front-operated.*

Disconnect switch is compact, self-contained unit. Capable of interrupting maximum locked rotor currents.

*No dead center*—Switch throws to *full* ON or OFF—no faulty indication. Also, mechanical interlock prevents opening door when switch is ON.

Write for new Bulletin 4120. WARD LEONARD ELECTRIC CO., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

## Mercury Thermal System

A 1,200 deg F Mercury Thermal System for industrial processing has been recently developed. This thermal system provides a simple, dependable and less expensive means of measurement and control of temperatures above the conventional 1,000 deg F indication. Such applications as gas-fired ovens, annealing ovens, high temperature blanchers, measurement of exhaust gases and others can be accurately served with this new measuring system.

Outstanding features include a newly developed Bourdon Type spring, Type 347 stainless steel thermal element, compensation for varying case and ambient temperatures and uniformly graduated charts. Range spans of 1,000 F, 600 F, and 400 F or equivalent Centigrade are available in all standard Taylor indicating recording and controlling instruments. No system can be furnished in which the range starts at temperatures below 700 Fahrenheit.

*Taylor Instrument Co., Rochester 1, N. Y.*

## Low Cost Testing Machine

This new testing machine is extremely simple in design and operation. It is compactly and ruggedly constructed and offers industry and educational institutions a practical and convenient machine to conduct tensile, compression or transverse tests on materials. This machine is useful for production and quality control testing.

This LC type machine is provided with dual capacity ranges of 10,000 pounds and 1,000 pounds, and is guaranteed to meet Army, Navy, Federal and ASTM specifications. It is available in both hand operated and motor driven models. The hand operated model is for bench mounting; motor powered units are provided with stands which house the electrical controls.

*Tinius Olsen Testing Machine Co., Easton Rd., Willow Grove, Pa.*

## New Blind Rivets

Faster assembly and lower cost are among the advantages offered by two new blind rivets. One of these, the Pull-Through type, has no minimum grip limitation, and eliminates large diversified inventory. The other, the Self-Plugging type, has a grip range of 0.140 inches for any grip increment. The positive shank expansion insures ample hole-filling to meet all normal requirements. In addition, these rivets

have a feature which prevent splitting of the sleeve during formation of the blind head. The pin tail of the rivet is provided with pull grooves to assure positive driving.

These blind rivets are designated as Huck PT Pull-Through Type and Huck 9SP Self-Plugging Type. Both types are available in $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, and $\frac{1}{4}$ inches in diameter. Both are regularly furnished in aluminum alloys or cadmium-plated mild steel, with brazier or 100 deg countersunk heads.

*Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich.*

## Small Battery

Originally developed for hearing aids, this new, smaller "A" battery is now available for general applications. The new RM-1 battery is 0.625 in. in diameter, 0.644 in. high, weighs 0.39 oz and has a capacity of 1,000 milliampere hours. The complete line now includes "A" batteries with capacities from 1,000 to 3,600 milliampere hours, individual cells ranging from 300 to 3200 milliampere hours and stack assemblies in a wide variety of sizes and capacities. The manufacturer claims these features: long shelf life, uniform discharge voltage, high ratio of energy to volume and weight, resistance to impact and acceleration, constant no-load voltage, ability to operate under extreme pressure and temperature ranges, leak-proof and dimensionally stable, resistance to humidity and corrosion and no need for rotation.

*P. R. Mallory & Co., Inc., Battery Div., North Tarrytown, N. Y.*

## Metering Pump

Accurate control of fluid flow is possible with newly developed solenoid plunger pump. This electrically operated pump can be remotely controlled to vary the displacement by altering the number of strokes per unit time. In addition, the stroke length of the piston can be altered to produce a maximum displacement of 0.8 cubic inches per stroke. The rate of stroke movement is performed by means of an electronic timer which is installed in the control box. This timer, using very conservatively loaded components requires relatively no upkeep and is built to run continuously for years with no replacements. The pump requires no attention, once installed, as all working parts are self-lubricated.

The construction of this pump is precision-made and the use of Type 316 stainless steel plus direct coupling between solenoid plunger and piston

**semi-knife-edge bearing reduces frictional wear**

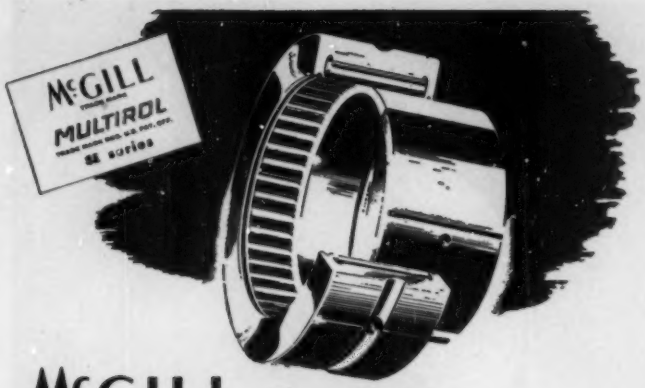
This is Ward Leonard's new Bulletin 110 Midget Relay for long, trouble-free service, particularly in equipments subject to vibration.

Exceptionally good vibration characteristics are due to proper proportioning of contact masses and springing combined with heavy pressures on both normally open and normally closed contacts.

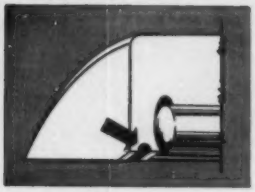
Higher contact ratings than most midgets. Available up to 3-pole, double throw. Contact finger leads are insulated with the new, impregnated glass-fiber tubing.

Write for Bulletin 110. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES




# McGILL design
## provides EXTRA oil seal protection



Extra protection against destructive foreign particles is provided by this lubricant-retaining groove, built into the inside diameter surface of the roller retaining-end shoulder. The ring of lubricant, held in this groove, acts against the inner race O.D., increasing the sealing effect of the precision tolerances between these shoulders and the inner race. Notice, too, the groove above the rounded end of the roller. Acting as a lubricant reservoir, this provides Multirol SE Series bearings with an extra margin of protection against neglected or delayed lubrication.

The increased life and lowered maintenance costs of Multirol bearings are accounted for by these built-in features, plus such design factors as greater load capacity and the elimination of loose or welded-in retaining rings. Multirol SE Series bearings, used with or without inner raceways in standard sizes of ⅝" to 9¼", are used extensively in machine tools, pumps, polishing machines, presses, power shovels, etc. — giving users a high degree of precision performance and longer bearing life.

*Why not consult McGill engineers for helpful recommendations in applying these benefits to your product? Write McGill Mfg. Co., Inc., Bearing Division, 201 N. Campbell St., Valparaiso, Indiana. Ask for Bulletin SE-47.*

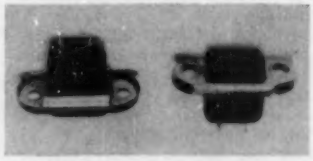
results in a highly efficient and compact unit with low power requirements. This unit has special mechanical sealing arrangement which eleminates stuffing box adjustments and periodic maintenance.

Overall size of the unit: timer approximately 9¾ x 4 x 5 inches high, pump 6½ x 4½ x 2⅝ inches deep.

*Eastern Industries, Inc., 296 Elm St., New Haven 6, Conn.*

## Electrical Outlet

This small UL approved auxiliary outlet is now being made with a double mounting plate for maximum rigidity —for equipment that must withstand rough usage. It requires mounting centers of only 1⅛ in. and 1 in. is sufficient clearance behind panel. The



0.140 in. diameter mounting holes permit quick assembly to panel by means of conventionally used ¼ in. eyelets or No. 6 screws. Body is molded of black phenolic although other colors are also available. The back of the molding is solid, thus completely eliminating any danger of the clip pushing out the back. Underwriters have approved this power outlet for 15 amps at 125 volts and 10 amps at 250 volts.

*Alden Products Co., 117 N. Main St., Brockton 64, Mass.*

## Sealed Micro-Switch

A small-size hermetically-sealed snap-action switch is now available. The operation of this switch is unaffected by corrosive atmospheres, change in atmospheric pressure, or change in temperature. While this switch is designed for aircraft applications involving wide variance of temperature, extremes in air pressure, and hazardous atmospheres, its sealed vapor-proof character lends itself to industrial use in locations where atmosphere or splash of liquids make other switches unsuitable. These switches may even be operated under oil and other fluids.

The sealed case of the switch is metal and filled with inert gas under pressure. This sealed metal case is secured to a plastic mounting base to which are assembled No. 6 screw terminals, so arranged as to avoid strain on the glass beads which seal the con-

ductors into the metal case. The circuit arrangement of this switch is single-pole, double-throw. The current capacity at 28 v, d-c, is 25 amps, resistive; 10 amps, inductive. Length $1\frac{1}{16}$ in. width $\frac{1}{16}$ in, height $1\frac{7}{64}$ in.

The operating characteristics are:

| | |
|---|---|
| Operating force | 16 oz. p/m 6 oz. |
| Release force | 4 oz., min. |
| Movement differential | 0.020 in., max. |
| Pretravel | 0.065 in., max. |
| Overtravel | 0.010 in., min. |
| Contact break distance | 0.036 in., min. |

*Micro Switch, Freeport, Ill.*

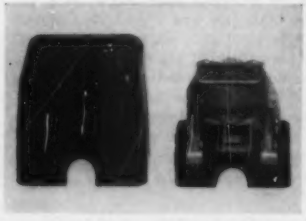
## Foot Treadle Switch

This compact switch has been designed with forward and reverse direction for industrial applications. It consists of two tiny compacts mounted in an aluminum base. A sturdy bridge is constructed between each compact to prevent accidental operation of both at one time. The actuating mechanism of the compact has been tested in industry and found to be fool-proof and extremely sensitive. This treadle switch, called the Twin Compact, is made of heavy gauge steel with a cork-composition, non-skid base. It is finished with black-crackle enamel and weighs only $18\frac{1}{2}$ ounces.

*Simonds Machine Co., Inc., Southbridge, Mass.*

## AC Motor Accelerating Relay

An improved voltage-type accelerating relay, designed specifically for starting single-phase, capacitor-start, and capacitor-start capacitor-run motors, has been announced. This relay will find its most common application



in the control of hermetically sealed refrigerator compressor motors. It can be furnished with or without cover, can be wired from top or bottom, and all parts are corrosion resistant. Extensive life tests prove that the relay easily withstands the most severe vibrations encountered in compressor application.

This relay coil is wired across the start winding of a single-phase motor. As the motor comes up to speed, the voltage induced in the start winding


The ABC of MST

Michigan

A ALWAYS MAKES POSSIBLE
B BETTER PRODUCTS
C AT LOWER COST

WELDED STEEL TUBING

ROUND

SQUARE-RECTANGULAR

Thousands of products, from intricate automobile and truck parts to furniture and vacuum cleaners, are made better and more economically with MICHIGAN TUBING. We invite you to consider the many advantages of using it in the fabrication of YOUR product.

*A Quality Product,* can be worked in your plant or prefabricated by MICHIGAN.

Consult us for engineering and technical help in the selection of tubing best suited to your needs.

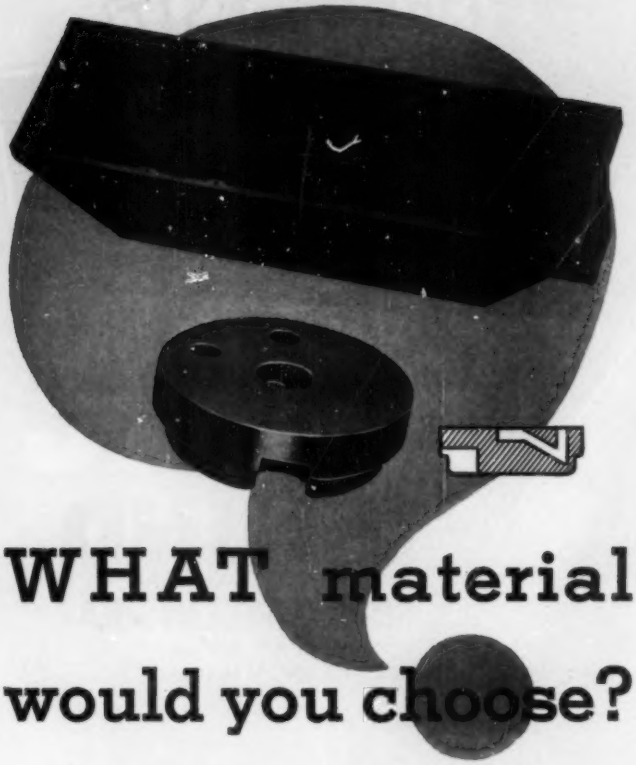
Michigan STEEL TUBE PRODUCTS CO.

32 Yrs. in the Business

9450 BUFFALO STREET • DETROIT 12, MICHIGAN

FACTORIES: DETROIT, MICHIGAN • SHELBY, OHIO

DISTRIBUTORS: Steel Sales Corp., Detroit, Chicago, St. Louis, Milwaukee, Indianapolis and Minneapolis—Miller Steel Co., Inc., Hillside, N. J.—C. L. Hyland, Dayton, Ohio—Dirks & Company, Portland, Oregon—James J. Shannon, Milton, Mass.—Service Steel Co., Los Angeles, Calif.—American Tubular & Steel Products Co., Pittsburgh, Pa.—Strong, Carlisle & Hammond Co., Cleveland, Ohio.



# WHAT material would you choose?

**1.** CHEMICAL FEED TANK: Part of control unit in commercial cleansing machine handles sodium hypochlorite, acetic acid, hydrofluoric acid, with fumes so corrosive they attack stainless steel. What economical, corrosion-resistant molding material is widely used for problems like this?

**2.** SODA WATER TUMBLER, small part for soft drink dispenser. Must be odorless, tasteless, unaffected by syrups, with low moisture absorption. Should provide tight fluid seal, with excellent dimensional stability. Tough production problem, too, in angle holes. How would you tackle this?

*Answers:* No. 1—Molded Ace Hard Rubber keeps corrosive solutions in their place, may solve your corrosion problems too. No. 2—Again Ace Hard Rubber was ideal. Small holes were drilled after molding this part.

Sometimes it's hard rubber—and sometimes it's one of the other plastics that's best. Ace, with many hard rubber and plastics compounds to choose from, is fully equipped to supply whatever you need. If you want this kind of impartial advice from your molder, select American Hard Rubber Company.

**Ask for ACE Handbook**

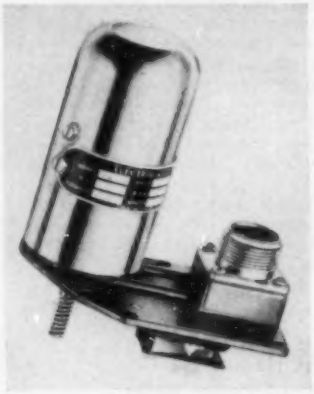
ACE — HARD RUBBER and PLASTICS
AMERICAN HARD RUBBER COMPANY
11 MERCER STREET • NEW YORK 13, N. Y.

increases. When the proper value of pickup voltage is reached, the relay picks up, thus taking the start winding out of the circuit at the desired speed. The voltage principle employed eliminates voltage drop at motor terminals usually encountered with current-type relays. Extremely wide differential between pickup and drop-out voltage gives positive operation of the control despite wide variations in line voltage.

*General Electric Co., Schenectady 5, N. Y.*

## Small D-C Motor Has Built-In Brake

Model 1301 is a high-speed, reversible, 1/100 hp d-c motor, with built-in electrical mechanical brake, and is designed for rotating or linear-motion



jobs where extreme precision of movement is needed, and where the motor must be stopped from top speed in the minimum number of turns. The specially-designed brake inside the motor is tamper-proof and is preset at the factory. Running torque is 1.1 in. oz at 19,000 rpm and at 28 v, dc; the brake operates within the range of 18 to 30 volts. Dimensions (excluding worm gear) are 3.5 in. by 1.75 in. diameter; the mounting plate measures 2.7 in. by 3.4 in.; and full weight of the motor is slightly more than 1 pound.

*Electro Aire, Inc., 11439 Vanowen St., North Hollywood, Calif.*

## Work Illuminating Spotlight

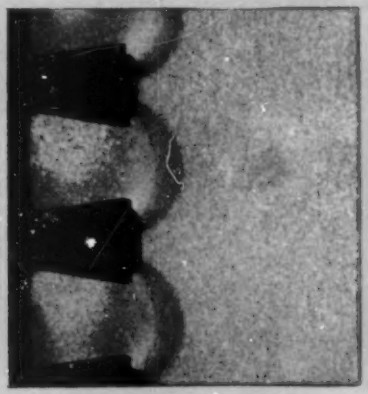
This spotlight is a versatile unit which can be attached to machines and maintain an intense light for intricate machine or inspection work. It is easily positioned by means of a ball and socket joint. An adjustment is provided to control the concentrated

# EVERDUR

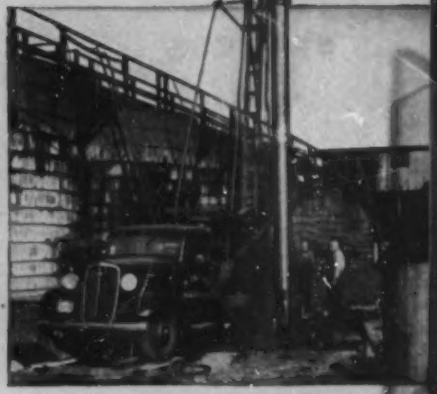
**Famous for exceptional resistance to corrosion, high strength, and adaptability to money-saving fabricating methods.**

Cross sections, slightly enlarged, of special shaped wire and rod members.

Well screen being fabricated by unique method of resistance welding.



Micrograph of lengthwise section showing excellent fusion of Everdur resistance welds.



Johnson Well Screen, 16" O. D., 35' long, being lowered into well casing.

Longitudinal rods and outer wire in this Edward E. Johnson, Inc., well screen are both Everdur* 1010 and of special cross section. Fabrication of the screen is quickly and economically accomplished by rotating the rod assembly, thus winding on the wire and automatically welding wire to rod by electrical contact.

The circuit is arranged so that the rod assembly becomes one electrode, the other electrode being a copper roll which rides on the wire. As the latter touches each rod a surge of current welds the wire to the rod. Welding is at the rate of from 900 to 1700 welds per minute, depending on the size of the wire and rod. Only two or three cycles of current are required for each weld.

Everdur Alloys are non-magnetic and highly resistant to fatigue. Alloys are available which can be machined, hot-forged, drawn, stamped, spun, cast, electric-welded or oxy-acetylene-welded by all modern methods and equipment. For detailed information regarding compositions, properties, applications and advantages, ask for Publication E-5. Our Technical Department is at your service. Write The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

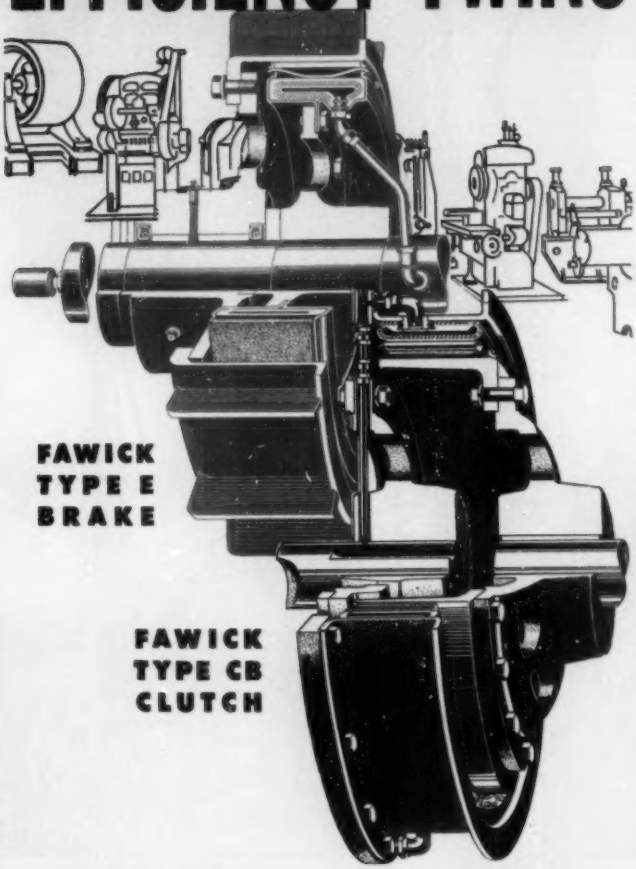
*Reg. U. S. Pat. Off.

**Where corrosion resistance counts—consider Everdur**

**ANACONDA**

**COPPER-SILICON ALLOYS**

# EFFICIENCY TWINS




## FOR POWER TRANSMISSION

When machine specifications call for efficiency, the logical answer is Fawick Clutches and Brakes.

Working individually or in combination, they provide Fawick-equipped machines with those operating characteristics which result in top machine performance. Quick response, positive action and control, elimination of lubrication, mechanical linkage and clutch adjustment comprise some of these advantages. The rugged design and construction provide long trouble-free machine operation in heavy-duty service.

For specific information on all advantages of Fawick Industrial Clutch and Brake Units, write to the Main Office, Cleveland, Ohio, for Bulletin 300.

All desirable clutch characteristics are built into Fawick Airflex units

FAWICK Airflex CO., INC.
CLEVELAND 11, OHIO


area of light. It is a sturdily made unit, entirely chrome plated, with a special lens to permit a sharp definition of the light beam in a wide range of diameters. It can be equipped with a transformer of 110 or 220 volt, depending upon the line voltage required.

*Sciaky Brothers, Inc., 4915 W. 67 St., Chicago, Ill.*

## Offset Conduit Nipples

These fittings cut installation time by simplifying the job of pipe alignment and result in a neater installation. Where box knockouts do not line up, these offset conduit nipples simplify the connection. These fittings also permit quick and perfect alignment of

ganged distribution boxes, pull boxes, switch enclosures, etc. In cases where the conduit-runs emerge from concrete, these offset nipples usually permit ready alignment without time consuming conduit bends. The available sizes are: $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, and 2 inches. All nipples have a $\frac{3}{4}$ inch offset with $1\frac{3}{4}$ inches between shoulders for uniform spacing. These are made of Malleable Iron, and are permanently rust-proofed with a special finish.

*Gedney Electric Co., RKO Building, Radio City, New York 20, N. Y.*

## Pneumatic Throttling Control

A new pneumatic power unit has been announced which can be used for operating valves, dampers and other control devices. This unit, called Roto-motor, features a reversible pneumatic motor, and a gear-driven screw stem. In addition, this stem is self-locking and a handwheel is attached for manual operation.

With this pneumatic control, accurate positioning is possible within 1/500 part of the stem travel and with stem loads up to 10,000 lbs. The stem travel can be as large as 20 inches and a maximum stem speed of 12 inches per minute. The type of mechanism used in this drive makes positioning very stable.

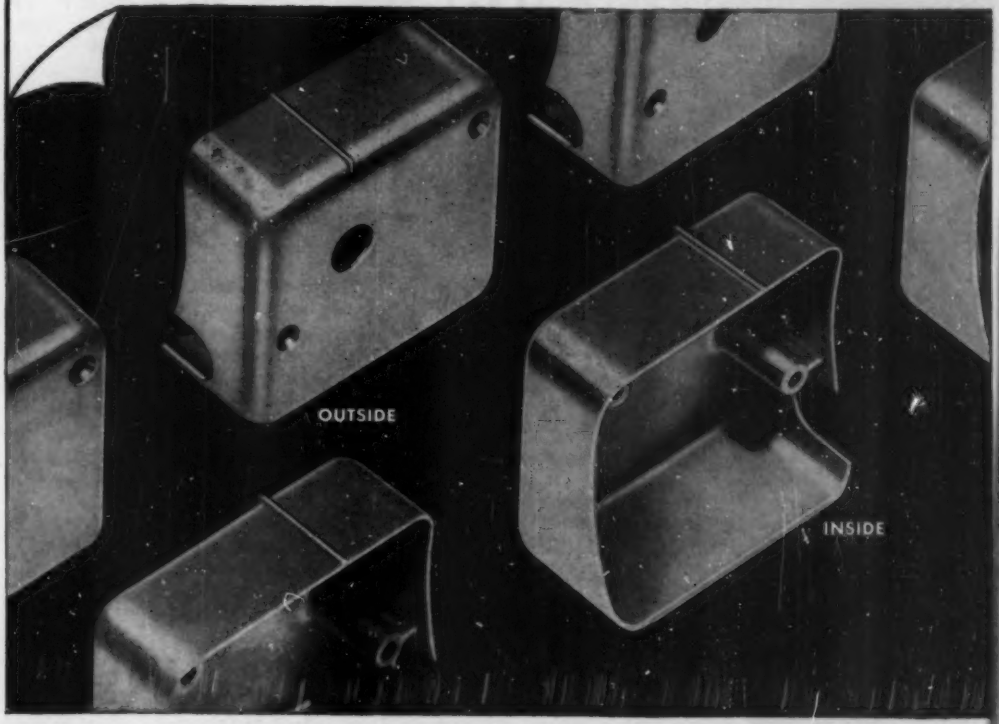
*Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.*

# EARMARKS OF QUALITY AT LOW COST WITH MADISON-KIPP ZINC AND ALUMINUM DIE CASTINGS

Designers of many home appliances have a valuable formula for adding the "quality look" at minimum cost.

The switch cover here illustrated is a good example of this type of intelligent designing. A "tinny" cover would definitely detract, whereas a well-designed die cast cover provides a prominent earmark of quality. The functional bosses, holes, index pointer, and perfect contour fit are plus values.

Designers who have questions in reference to die castings are invited to send their letters to our home office in Madison, Wisconsin.



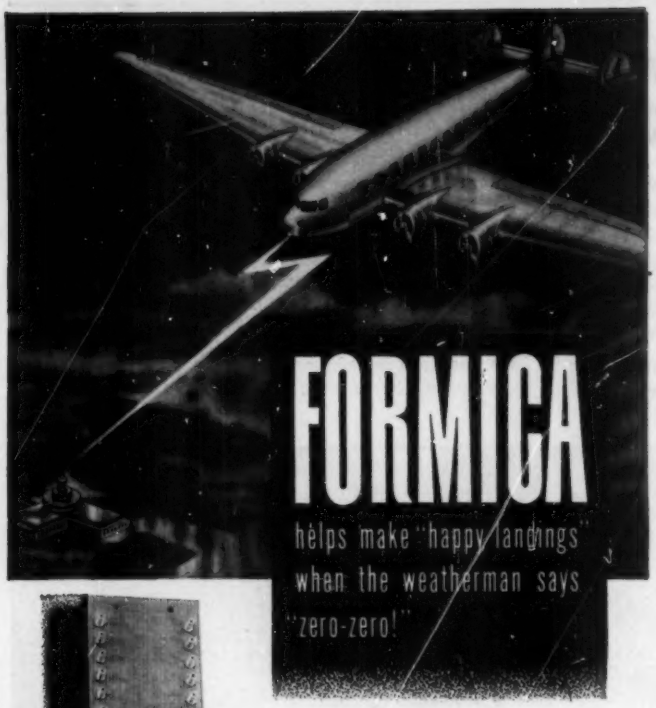

## MADISON-KIPP CORPORATION

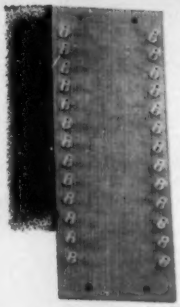
206 WAUBESA STREET, MADISON 10, WIS., U.S.A.

ANCIENS ATELIERS GASQUY, 31 Rue du Marais, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- Skilled in DIE CASTING Mechanics
- Experienced in LUBRICATION Engineering
- Originators of Really High Speed AIR TOOLS



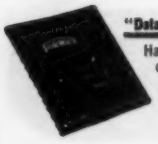



*GCA, for Ground Controlled Approach, is aviation's most important navigation aid. Many hundreds of pilots owe their safety to GCA systems built by the Los Angeles firm of Gilfillan, manufacturer for USAF and CAA.*

**AT THE HEART OF** the Gilfillan CCA system is the terminal board, above. Gilfillan engineers chose Formica for this vital component on the basis of outstanding arc and heat resistance. "The grade that makes the grade," in this case, is Formica G-6—a glass fabric base plastic laminate, bonded with silicone resin. Low moisture absorption is another "plus value" offered by Formica glass-silicone grades.

**FORMICA IS AVAILABLE** in more than 40 "standard" grades, each high in electrical, mechanical or chemical resistant properties, whichever is most desirable. Formica sales engineering research is continually developing special grades for specific applications in sheet, tube, rod or molded form. This service is always available to help solve your laminated plastics problems. Write FORMICA, 4676 Spring Grove Ave., Cincinnati 32, Ohio.

**FORMICA GLASS-SILICONE GRADES** also offer low dielectric losses in radio and power frequencies, and are highly resistant to chemicals.



**"Data for Industry"**

Handy 96-page reference book on all grades of Formica—is yours, personally numbered and postpaid, for $1.00. Send for your copy today.

Productive
FORMICA
at Work in Industry


# MEETINGS

March 9-11
OPTICAL SOCIETY OF AMERICA—Winter Meeting, Hotel Statler, New York.

March 14-16
SOCIETY OF AUTOMOTIVE ENGINEERS—Passenger Car, Body and Production Meeting, Book-Cadillac Hotel, Detroit, Mich.

March 16-17
PRESSED METAL INSTITUTE—Symposium on Cold Extrusion of Steel, Hotel Carter, Cleveland, Ohio.

March 21-22
STEEL FOUNDERS' SOCIETY OF AMERICA—Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

March 28-31
SOCIETY OF THE PLASTICS INDUSTRY—National Plastics Exposition; Navy Pier, Chicago, Ill.

April 4-7
NATIONAL ASSOCIATION OF CORROSION ENGINEERS—Annual Conference and Exposition, St. Louis, Mo.

April 10-12
AMERICAN SOCIETY OF LUBRICATION ENGINEERS—Annual Meeting, Hotel Statler, Detroit, Mich.

April 10-14
AMERICAN SOCIETY OF TOOL ENGINEERS—Industrial Exposition on Cost Cutting, Convention Hall, Philadelphia, Pa.

April 12-14
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Spring Meeting, Hotel Statler, Washington, D. C.

April 17-19
SOCIETY OF AUTOMOTIVE ENGINEERS—Aeronautic Meeting and Display, Hotel Statler, New York.

April 24-26
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Process Industries Division Conference, Hotel William Penn, Pittsburgh, Pa.

April 24-27
AMERICAN MANAGEMENT ASSOCIATION—19th National Packaging Exposition, Navy Pier, Chicago, Ill.

April 25-26
METAL POWDER ASSOCIATION—Annual Metal Powder Show, Book-Cadillac Hotel, Detroit, Mich.

May 5-6
AMERICAN PHYSICAL SOCIETY—National Meeting and Midwestern Conference on Fluid Dynamics, University of Illinois, Urbana, Ill.

# SPEED!

## Only ZINC DIE CASTINGS OFFER THE LOW COST OF THE FASTEST DIE CASTING MACHINES

### 1800 CASTINGS PER HOUR

This is a plunger machine—the fastest die casting machine there is. It is turning out "gates" of 4 castings at a rate of 450 per hour—2 pairs of automobile horn bodies per "gate"—1800 ZINC die castings per hour. Of the most used die casting metals, *only ZINC alloy can be cast in this high speed machine.*

### RAPID TRIMMING

Since ZINC die castings can be produced with extreme complexity of shape, many castings require no machine work other than removal from the "gate" and trimming of flash. This is accomplished on the horn body "gate" in one motion of a punch press, as shown here. At each opening of the press, out fall 4 complete castings. The trimmed metal is not wasted, since it is remelted and used for subsequent castings.

### READY FOR ASSEMBLY

As the castings come from the punch press they are ready for assembly. Here they are inspected and packed in cartons for shipment to the customer. It is easy to see why *die casting is the shortest distance between raw material and finished part.*

Speed of production is only one of many reasons why ZINC die castings are the most widely used. Every die casting company is equipped to make ZINC die castings and will be glad to discuss these reasons with you. Or write to us.

**ZINC**
FOR DIE CASTING ALLOYS

The New Jersey Zinc Company, 160 Front Street, New York 7, New York.

The Research was done, the Alloys were developed, and most Die Castings are based on
**HORSE HEAD SPECIAL** (99.99+% Uniform Quality) **ZINC**

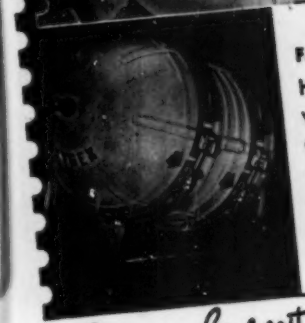
# engineer's notebook

**FOR HANDLING SHOCK LOADS**

Secure overflow cylinder to landing gear shimmy dampener with Marman T-bolt clamps, especially suited to severe shock loads encountered in this installation.

**JET ENGINE JOINT CONNECTIONS**

Marman V-Band couplings provide an efficient seal and facilitate maintenance with quick disconnect provisions of the coupling latch.



**FASTENING OXYGEN BOTTLES**

Holding straps and clamps must withstand a resultant force in any direction of 3500 lbs. Standard Marman types fulfill all requirements and can be adapted to any specific design.

*Save cost and design time with Marman*

FOR INFORMATION WRITE DEPT. W-7

THE BEST CLAMPS, STRAPS AND COUPLINGS

MARMAN PRODUCTS CO. INC.

940 WEST FLORENCE AVE.

INGLEWOOD, CALIF.


# OUR READERS SAY

## Erratum

*To the Editor:*

In the calculation cited on Page 109 of the December, 1949 issue of PRODUCT ENGINEERING for the length of blank required for upheading, the example referred to in the article entitled, "Product Possibilities for the Cold Heading Process", is I believe in error. The calculated length should be 3.2 in. instead of 0.78. E. L. FOWLER
*International Nickel Co.*

Ed—Now here's an error that we can't even blame on the printer—it's just a plain, old fashioned mistake.

## Titanium Wire

*To the Editor:*

The special PRODUCT ENGINEERING progress report on titanium, appearing in the November issue, was of great value to our engineering staff.

On page 150 reference is made to alloys of aluminum-chromium-titanium. Can you advise where we can obtain experimental quantities of these alloys. We are particularly interested in obtaining wire specimens of small diameter. Any information you can give us on this subject will be greatly appreciated. —J. H. THORNBERY
*Milwaukee Gas Specialty Co.*

Ed—For samples of aluminum-chromium-titanium we suggest that you contact Mr. Skylar Herres, Associate Director of Research, Allegheny Ludlum Steel Corp., Research Laboratories, Watervliet, N. Y. You might also try Dr. Gee of E. I. Du Pont de Nemours & Co., Newport, Del.

## Its Cheaper

*To the Editor:*

In the January 1950 issue of PRODUCT ENGINEERING, the article "Kinematics of Intermittent Mechanisms" is a very interesting study of the three-gear drive. The fact that the driven shaft can be made to rotate backward slightly, as well as stop, is sometimes useful for clearing tools, and is a feature difficult to obtain with such movements as the Geneva.

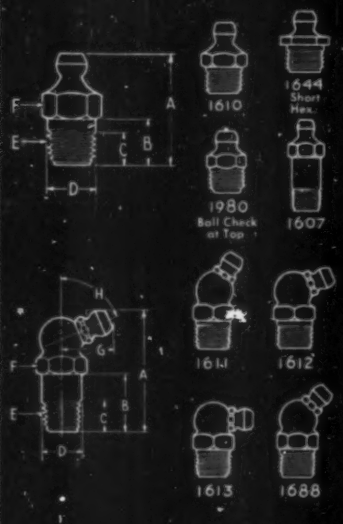
However, I wonder what practical

# *Genuine* ALEMITE LUBRICATION FITTINGS

**DATA SHEET NO. 1**

Simplify ORDERING, INSPECTION and INVENTORY CONTROL. Specify Alemite part numbers on your blueprints.

**Useful Information to Help You Select and Specify the Right Alemite Fitting for Every Bearing**




## STRAIGHT HYDRAULIC FITTINGS

| Part No. | A | B | C | D | E† | F |
|---|---|---|---|---|---|---|
| 1607 | 1 17/64" | 25/32" | 13/64" | 13/32" | 1/8" P.T. | 7/16" |
| 1610 | 31/32" | 17/64" | 13/64" | 25/64" | 1/8" P.T. | 7/16" |
| 1618 | 1 7/64" | 5/16" | 1/4" | 1/2" | 1/8" P.T. (Female) | 1/2" |
| 1634 | 13/16" | 5/16" | 1/4" | 13/32" | 1/8" P.T. | 7/16" |
| 1644 | 21/32" | 5/16" | 1/4" | 13/32" | 1/8" P.T. | 7/16" |
| *1650 | 57/64" | 3/8" | 19/64" | 13/32" | 1/8" N.P.T.F. | 7/16" |
| 1669 | 1 3/64" | 1 17/64" | 1/4" | 13/32" | 1/8" P.T. | 7/16" |
| 1684 | 2 3/4" | 2 7/16" | 5/16" | 13/32" | 1/8" P.T. | 7/16" |
| *1708 | 55/64" | 25/64" | 19/64" | 13/32" | 1/8" N.P.T.F. | 11/32" |
| 1980 | 41/64" | 17/64" | 1/4" | 13/32" | 1/8" P.T. | 7/16" |

*Leak-proof seal
†Thread size listed as 1/8" P.T. is 1/4" P.T.F.—SAE EXTRA SHORT

## 1/8" THREAD ANGLE HYDRAULIC FITTINGS

| Part No. | A | B | C | D | E† | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1606 | 1 13/16" | 1" | 3/8" | 13/32" | 1/8" P.T. | 7/16" | 15/32" | 90° |
| 1611 | 1 1/64" | 17/64" | 13/64" | 25/64" | 1/8" P.T. | 7/16" | 23/64" | 30° |
| 1612 | 33/64" | 17/64" | 13/64" | 25/64" | 1/8" P.T. | 7/16" | 1/2" | 67 1/2° |
| 1613 | 49/64" | 17/64" | 13/64" | 25/64" | 1/8" P.T. | 7/16" | 23/64" | 45° |
| 1614 | 1 5/64" | 5/16" | 1/4" | 13/32" | 1/8" P.T. | 7/16" | 31/64" | 105° |
| 1620 | 1 5/16" | 13/32" | 5/16" | 7/16" | 1/8" P.T. (Female) | 7/16" | 17/32" | 45° |
| 1623 | 1 3/16" | 5/16" | 1/4" | 13/32" | 1/8" P.T. | 7/16" | 31/64" | 67 1/2° |
| 1638 | 2 9/32" | 1" | 7/16" | 13/32" | 1/8" P.T. | 7/16" | 23/64" | 30° |
| 1640 | 2 25/32" | 2 5/16" | 5/16" | 13/32" | 1/8" P.T. | 7/16" | 39/64" | 67 1/2° |
| *1651 | 1" | 49/64" | 19/64" | 13/32" | 1/8" N.P.T.F. | 7/16" | 1/2" | 67 1/2° |
| 1688 | 61/64" | 17/64" | 13/64" | 25/64" | 1/8" P.T. | 7/16" | 27/64" | 45° |
| *1692 | 1 7/32" | 5/8" | 19/64" | 13/32" | 1/8" N.P.T.F. | 7/16" | 31/64" | 30° |
| *1693 | 15/16" | 5/8" | 19/64" | 13/32" | 1/8" N.P.T.F. | 7/16" | 31/64" | 90° |
| *1950 | 1 1/8" | 5/8" | 19/64" | 13/32" | 1/8" N.P.T.F. | 7/16" | 19/32" | 105° |

*Leak-proof seal. †Thread size listed as 1/8" P.T. is 1/4" P.T.F.—SAE EXTRA SHORT

## 1/4" PIPE THREAD HYDRAULIC FITTINGS

| Part No. | A | B | C | D | E† | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1627 | 15/16" | 31/64" | 9/32" | 11/16" | 1/4" P.T. | 9/16" | ..... | ..... |
| 1629 | 1" | 11/16" | 5/16" | 17/32" | 1/4" P.T. | 9/16" | 9/16" | 67 1/2° |
| 1691 | 1 11/64" | Female Thread | | | 1/4" P.T. | 9/16" | ..... | ..... |

†Thread size listed as 1/4" P.T. is 1/4" P.T.F.—SAE EXTRA SHORT.

## 1/4"—28 THREAD HYDRAULIC FITTINGS

| Part No. | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1636 | 31/32" | 19/64" | 1/4" | 17/64" | 1/4"-28 Taper USF-Thd. | 9/16" | 9/16" | 45° |
| 1637 | 17/32" | 11/64" | 1/4" | 1/4" | 1/4"-28 Taper USF-Thd. | 9/16" | 9/16" | 45° |
| 1641 | 31/64" | 13/64" | 1/4" | 1/4" | 1/4"-28 Taper USF-Thd. | 9/16" | ..... | ..... |
| 1652 | 43/64" | 23/64" | 1/4" | 1/4" | 1/4"-28 Taper USF-Thd. | 9/16" | ..... | ..... |
| 1680 | 59/64" | 29/64" | 1/4" | 17/64" | 1/4"-28 Taper USF-Thd. | 9/16" | ..... | ..... |
| 1698 | 1 7/64" | 31/64" | 1/4" | 17/64" | 1/4"-28 Taper USF-Thd. | 17/32" | ..... | ..... |
| 1703 | 1/2" | 7/32" | 1/4" | 1/4" | 1/4"-28 Taper USF-Thd. | 17/32" | ..... | ..... |
| 1770-A | 19/32" | 1/8" | 1/4" | 1/4" | 1/4"-28 NF-2-Thd. | 9/16" | 29/64" | 45° |
| 1792 | 1/2" | 9/64" | 1/4" | 1/4" | 1/4"-28 NF-2-Thd. | 17/32" | ..... | ..... |
| 1911 | 47/64" | 17/64" | 1/4" | 1/4" | 1/4"-28 Taper USF-Thd. | 9/16" | 19/32" | 90° |

**ALEMITE**
*Modern Lubrication Methods That Cut Production Costs*

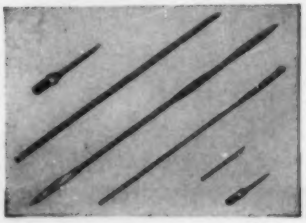
**FREE!** Complete set of four Data Sheets similar to this, giving specifications on all types and sizes of Alemite Lubrication Fittings. Simply write to Alemite, Dept. T30, 1850 Diversey Parkway, Chicago 14, Illinois.

Another Product of STEWART WARNER

CUT COSTS

have your metal parts precision-made by

TORRINGTON

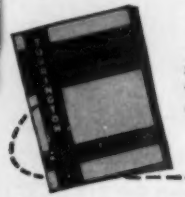


Special equipment and volume production enable us to make precision parts for you at much lower costs.

For example, highest quality special needles for textile, leather, paper, etc., machinery. Pins for printing presses and surveyors' instruments. Special equipment assures proper heat-treatment . . . accurately formed eyes, grooves and shanks . . . precisely sharpened points . . . clean milling, knurling, slotting, and bevelling. Needles hand-straightened.

Send your prints and specifications today for a prompt quotation, and ask for a copy of "Precision Metal Parts".

THE TORRINGTON COMPANY
*Specialty Department*
554 Field Street • Torrington, Conn.



Send coupon today for your free copy of this booklet.

Name_____
Firm_____
Address_____
_____


advantage this three-gear design has over a cylinder-cam mechanism, which can also give any desired brevity of stop, as well as a slight backward motion?

M. W. WAGNON
*New York City*

Ed—The three-gear system is much cheaper. As Mr. Rappaport stated in his article, these gear systems are made from standard, stock gears.

### He Liked It

*To the Editor:*

I would like to congratulate Mr. H. F. Bariffi for his "Nomogram for Angles in Constructed Shapes", (PRODUCT ENGINEERING, page 157, January issue).

This type of nomogram is always useful; it is no mere substitute for a simple and easily solved first degree equation, but a real time saver.

—H. S. B.
*New York City*

Ed—We agree.

## *Where Can I Get It?*

### Syncro Devices

*To the Editor:*

Please let me know if you have any data on the Selsyn Device (G.E.) in use as a remote control for an air valve.

I am concerned with a transmitter and a remote receiver control operating an air valve through a differential or another similar method of correction.

Any material you can furnish as to manufacturers or types of applications will be greatly appreciated.

—FRANCIS T. LAURIN
*E. D. Jones & Sons Company*

Ed—For manufacturers of a-c or d-c Selsyn devices, you should contact General Electric Company, Schenectady, New York; Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin; Westinghouse Electric Corporation, Pittsburgh, Pa.

Watch our March and April issues for two good articles on the selection and application of d-c synchro devices.

### Metalized Glass Tubing

*To the Editor:*

We need a source of supply for glass tubing that can be hermetically sealed. The tubing must have a ¼ in. band of silver or platinum at each end to allow a connection to be sol-


"Springs are Springs"

maybe so for most people . . . but NOT for ACCURATE

HOW often have you heard a spring user or even a manufacturer say "Springs are springs, what difference who makes them if the price is right?" Here at Accurate, we think it makes a big difference and our experience proves it. *Exact* conformance to specifications can be mighty important if it means easier, faster assembly and better performance for your product. Quality control is important, too, when it saves you time and trouble. "Know-how" and facilities for making springs the least costly way can mean many dollars for you.

It all adds up to lower overall spring costs for you and that's what we at Accurate have to sell. Before you place your next spring order we would like to show you what it means to you in particular. There's no obligation; write today.

Accurate Springs

COST CONSCIOUS QUALITY
Since 1930

ACCURATE SPRING MFG. CO.
3815 W. Lake St. • Chicago 24, Ill.
*Springs, Wire Forms, Stampings*

# A.O.Smith Builds ELECTRIC MOTORS

**THE GRIMES AIR COMPRESSORS,** products of The Grimes Company, Dallas 1, are guaranteed to do the job for which they are built. Shown here is the single-stage, single-cylinder Model 75 for small shops, mounted on an extra-heavy 30-gal. tank air-tested up to 400 lb.

**A. O. SMITH ELECTRIC MOTOR** for The Grimes Model 75 Air Compressor illustrated is a ¾-hp, single-phase, 1725-rpm, 115/230-v, 60-cycle standard motor with 40° C. rise. Rigid base, open, drip-proof construction, continuous duty.

**24-HOUR MOTOR SERVICE.** To more than 200 authorized service stations, A. O. Smith Product Service Division provides fast, low-cost electric motor service on a 24-hour, off-the-shelf basis. Factory Service Branches and Warehouses: Union, N.J., Chicago 17, Dallas 2, Los Angeles 12.

## For hundreds of products, including THE GRIMES AIR COMPRESSORS

Improved performance, compact design, economy: Does the power component in your product call for an electric motor with these prime requirements? Then consult the A. O. Smith sales engineer—for either standard or custom-built motors. To help integrate electric-motor design with your product design, he offers you the complete facilities of the A. O. Smith research and engineering staff. For more details, send the coupon.

***Ask the A.O. Smith sales engineer about electric motors for both standard and special uses***

A.O.Smith 76th ANNIVERSARY 1874 - 1950

**A.O.Smith**

ELECTRIC MOTORS

Boston • New York • Pittsburgh • Cleveland • Atlanta
Chicago • Detroit • Milwaukee • Washington, D.C. • Tulsa
Houston • Dallas • Denver • Seattle • Los Angeles
San Francisco
Motor Export Department: 13 East 40th St., New York 16

A. O. Smith Corporation, Dept. PE-350
3701 Smithway Street
Los Angeles 22, California

Without obligation, send us information on A.O. Smith Electric Motors.

Name_____

Firm_____

Street_____

City_____ State_____

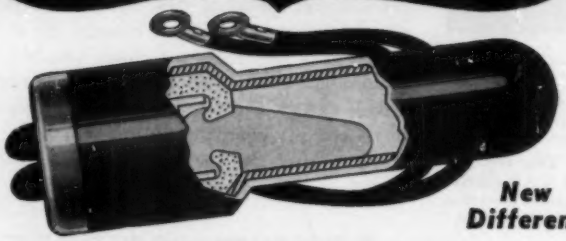
IF IT'S IRON OR STEEL

REMEMBER to have it HOT DIP GALVANIZED

(DIPPED IN MOLTEN ZINC)

Only HOT DIP Galvanizing provides the heaviest practicable coating of zinc *inseparably bonded* to the steel. For the longest-lasting economical rust prevention, specify "Hot Dip Galvanizing" done by a member of the American Hot Dip Galvanizers Association. List of member plants available by writing to the Association's headquarters in the First National Bank Building, Pittsburgh 22, Pennsylvania.

10 YEAR SWITCH



New Different

Prices Reduced 28% to 55% on same capacity

★ Twice capacity of older models
★ Hydrogen pressure increased
★ No sputtering or false contacts
★ No deterioration from inactivity
★ Withstands higher temperatures
★ Lower operating angles

5 New Models ask for BULLETIN 525

KEEPS COOL UNDER PRESSURE

NEW and IMPROVED

Steel Durakool

MERCURY SWITCHES and RELAYS

DURAKOOL, INC., 1010 N. MAIN ST., ELKHART, INDIANA
IN CANADA: CONTROLITE ENG. & SALES, LTD., TORONTO 5, ONTARIO

dered on. Sizes needed will vary from ⅛ to 1 in. in outside diameter and from 2 to 4 in. in length. M. FISHBERG
*United Condenser Co.*

Ed—You might try the Special Products Division of Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J., or the special products divisions of Sylvania Products, Inc., Salem, Mass.; and the General Electric Co. of Schenectady, N. Y.

## Fluid Magnetic Clutches

*To the Editor:*

I would appreciate your sending me the name of the manufacturer or sales representative of the Fluid Magnetic Clutches, 3rd item under Components, page 5 of your January issue.

—JOHN C. BETTS
*Penllyn, Pa.*

Ed—You should write Duncan & Bayley, Inc., at 785 Hertel Ave., Buffalo 7, N. Y.

## Safety Purifier

*To the Editor:*

Would you please give us more information on the "Safety Purifier" as mentioned on page 5 of the January 1950 issue of PRODUCT ENGINEERING.

We would like to have this information for reference to be used on our gas operated fork trucks.

If you do not have any information to give us, then would you be kind enough to forward the name of the company who manufactures this Safety Purifier and their address.

—F. A. VOSSENBERG
*The Yale & Towne Manufacturing Co.*

Ed—For full information write the United States Patent Office, Washington, D. C. (Patent # 2,488,563).

## Drawing Room Standards

*To the Editor:*

I have been a subscriber of PRODUCT ENGINEERING for some time and have not as yet come across a good source of Drafting Office standards. Could you please let your readers know by an answer in your column where to find such standards?

—THEODORE F. PIKE, JR.
*Ontario, Canada*

Ed—Both the ASME and the ASA publish a good set of drafting room standards. The first publishes "ASME Drawing Room Practice" and the second "Drawing and Drafting Room Standards". Addresses are: ASME, 29 W. 39th St., ASA, 70 E. 45th St., N. Y., N. Y.

FLIPPING A COIN IS OUT—
WE LEAVE NOTHING TO CHANCE
Here at Moraine, when we decide to accept your order for metal powder parts, we're not gambling on success —we're betting on a sure thing. Since we know powder metallurgy from Antimony to Zinc . . . since we know its limitations as well as its possibilities . . . we can determine in advance whether the powder metallurgy process will work to the advantage of the customer. If it will result in lowered costs and better performance, we get busy. If it won't, we pass up the order.
If you think that you are using parts that could advantageously be produced by powder metallurgy, why not ask Moraine's engineers? If the shape of a part permits good die fill and correct density . . . if its required physical properties and tolerances can be obtained by normal production methods . . . and if it is to be made in quantities sufficient to justify tooling costs . . . then, and only then, we will take on the job.
If we *do*, you can rest assured that, when your parts come through, they will improve your product and your operation . . . because we leave nothing to chance.
METAL POWDER PARTS BY MORAINE
MORAINE PRODUCTS
DIVISION OF GENERAL MOTORS
DAYTON, OHIO

THOMAS
Flexible ALL METAL
COUPLINGS
FOR POWER TRANSMISSION
REQUIRE NO MAINTENANCE

**Patented Flexible Disc Rings of special steel transmit the power and provide for misalignment and end float.**

Thomas Couplings have a wide range of speeds, horsepower and shaft sizes:
½ to 40,000 HP
1 to 30,000 RPM

***Specialists on Couplings for more than 30 years***

THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT.
NO MAINTENANCE PROBLEMS.
ALL PARTS ARE SOLIDLY BOLTED TOGETHER.

*Write for the latest reprint of our Engineering Catalog.*

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

# NEW BOOKS

## Electric Arc Welding

*544 pages, 5½ x 8 in. Published by Hobart Trade School, Box EW 146, Troy, Ohio.* $3.00.

This is a first class textbook for the electric welder but is not of primary interest to the design engineer. It does make a good reference for welding practice for the engineer who frequently designs welded structures.

Clearly written, the 28 chapters are divided in five parts: (1) General Information; (2) Operator Training Courses; (3) Carbon Arc Welding and Cutting; (4) Other Welding Processes; (5) Welding Terms and Their Definitions.

Part 1 discusses the development of electric arc welding, describes applications, available metals and alloys, joints and welds, electrodes, equipment and other basic procedures.

Part 2 constitutes a complete self-study course, incorporating review summaries, practical exercises and "quiz" questions.

Part 3 describes in detail the principles and practical operations of carbon arc welding.

Part 4 covers other welding processes such as Inert-Gas-Shielded Arc Welding, Submerged Arc Welding, and Electric Stud Welding.

Part 5 reproduces the welding terms and their definitions of the American Welding Society.

The textbook is illustrated with over 600 photographs of operations, diagrams and charts.

## James Watt And The History of Steam Power

IVOR B. HART. *250 pages, 6 x 9 in. Published by Henry Schuman, 20 E. 70th St., New York 21, N. Y.* $4.

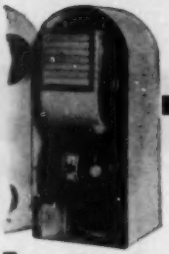
Since the development of the steam engine started the Industrial Revolution, James Watt stands as one of the founders of the civilization we know today. His work is the culmination of centuries of speculation and experiment from Leonardo da Vinci to Thomas Newcomen.

Dr. Hart deals lucidly with the forerunners of Watt:

Da Vinci, who attempted a quantitative experiment on the expansion of steam.

Della Porta, the gifted and popular Neapolition philosopher who suggested designs for steam-powered water pumps.

Edward Somerset, Second Marquis of



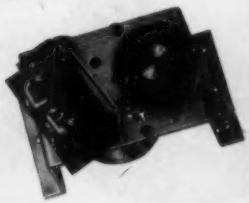
AUTOMATIC HAND DRYER
OPERATED BY
*Cramer*
CYCLE TIMER

A product of Electric-Aire Engineering Corp., the Electric-Aire Hand Dryer provides completely automatic and uninterrupted hand drying service in schools, theatres, offices, hospitals, factories, etc. Dries hands quickly, thoroughly . . . helps keep washrooms cleaner.

To assure dependable, trouble-free operation, Electric-Aire Dryers are equipped with a Cramer CF5 (Single Pole) Cycle Timer. Activated when "start" button is depressed, timer energizes heater and fan motor, and automatically de-energizes them at end of predetermined 37½ second drying period.

"Gruelling tests of all electrical and mechanical components were made under the close and constant supervision of our own corps of engineers before their use in the regular production of Electric-Aire Hand Dryers."

Another example of precision timing . . . by Cramer.



TIMING PROBLEM?

If the performance of your product depends on precision timing, send us full particulars about your application. In developing a range of devices — Time Delay Relays, Interval Timers, Percentage Timers, Running Time Meters, Synchronous Motors — for a great variety of commercial and industrial timing duties, we have had wide experience in the design of equipment to meet many specific needs . . . and will welcome the opportunity to assist in solving your problem.

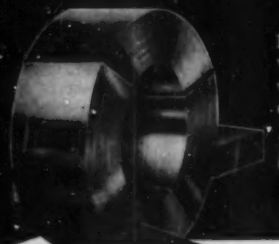
THE R. W. CRAMER COMPANY, INC.
BOX 7, CENTERBROOK • CONN.

# BEHIND THESE GALVANITE CONVEYOR ROLL SPACERS OF INTEREST TO EVERY STEEL FABRICATOR

THE spacer tubes pictured on this page were Superformed* directly from coils using a progressive die on an OBI press. The National Formetal Division Federal-Mogul Corporation believes this method gives them better concentricity in their product—faster at lower costs.

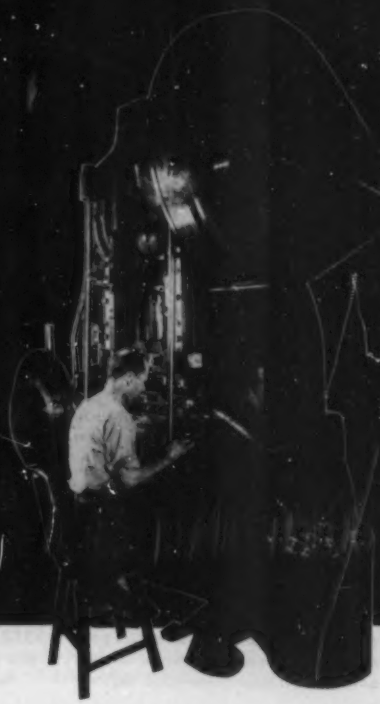
The metal used in this operation is important. It must be uniform of gauge and hardness, and must be able to take the severe forming without breaking or scarring. Because conveyors are often used in the open, the steel must be weather-resistant.

To conform with these specifications National Formetal found **Galvanite** ideal. By using Galvanite they were able to discard the coating operation—a move that saved time, speeded delivery, and cut more than a cent and three-quarters off each pound of finished spacers.



If you are manufacturing a product that is subjected to the weather it will pay you to check with Sharon — sole producers of **Galvanite.**

*Trade Mark of National Formetal

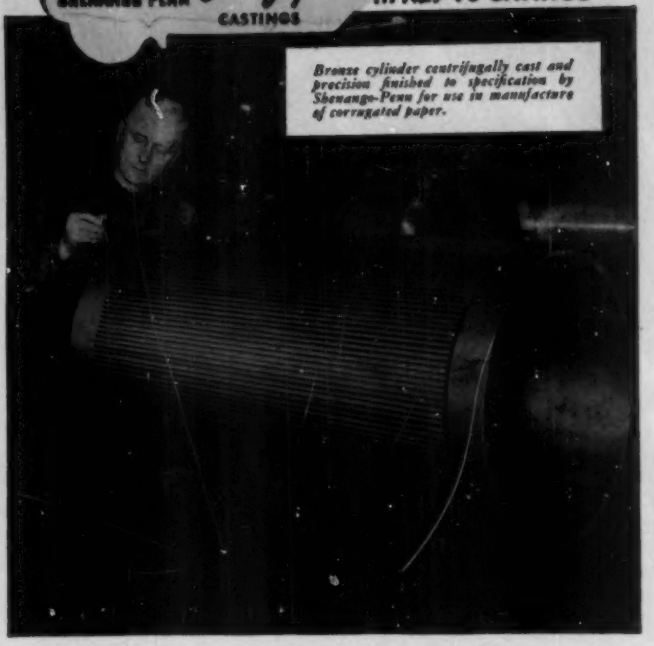


SHARONSTEEL

## SHARON STEEL CORPORATION

*Sharon, Pennsylvania*

SHENANGO-PENN Centrifugal CASTINGS ... KEY TO SAVINGS


Bronze cylinder centrifugally cast and precision finished to specification by Shenango-Penn for use in manufacture of corrugated paper.

**Major parts last longer ... cost less!**

TAKE this special bronze forming roll cover, for example. Because it is a Shenango-Penn *centrifugal* casting, it combines complete uniformity, exceptionally fine, pressure-dense grain, and freedom from blow holes, sand inclusions and other common, often hidden defects.

The money-saving result, quite naturally, is greatly prolonged wear life and the plus strength that will take abnormal loads and speeds without risking costly failure in service.

This is just one of the countless types of cylinders, sleeves, liners, rings, rolls and roll assemblies produced by Shenango-Penn in ferrous and non-ferrous metals for various industries. When *you* need such parts . . . rough, semi-machined or precision finished, small or large . . . specify Shenango-Penn and profit by Shenango-Penn's specialized processes, facilities and experience.

**MEANWHILE, ASK FOR BULLETIN**

**No. 143**—Centrifugal castings of non-ferrous metals and alloys.

**No. 144**—Centrifugal and static castings of plain and alloyed irons.

**No. 145**—Centrifugally cast bushing stock in all standard sizes.

**SHENANGO-PENN MOLD COMPANY**
682 West Third Street Dover, Ohio
Executive Offices: Pittsburgh, Pa.

SHENANGO (P) PENN

All Bronzes • Monel Metal • Ni-Resist • Meehanite Metal

Worcester, who designed an early steam engine.

Christian Huyghens, whose engine was a precursor of the internal combustion engine.

Thomas Savery, who developed the first practical steam engine.

Denis Papin, the Frenchman who became Curator of the British Royal Society, and invented a "digester"—virtually a pressure cooker—for which he devised the first steam safety valve.

Thomas Newcomen, whose steam-driven water pumps were used throughout Europe for draining mines and swamp lands, and for providing city water.

It was these steam-driven water pumps of Newcomen which gave Watt the final mechanism upon which he could focus his engineering genius.

Dr. Hart provides the first comprehensive picture of the social and economic needs which gave impetus to Watt's great engineering achievements, and he provides too a very human portrait of Watt and the men to whom he was indebted.

No one can have a complete understanding of technological evolution or of industrial progress in the 18th and 19th centuries without knowledge of Watt, of the society in which he worked, and of his predecessors. Dr. Hart imparts that knowledge clearly, compactly, and very readably, for both the student and the general reader.

## Design of Direct Current Machines

L. GREENWOOD. 222 *pages*, 6 x 9 *in. Published by MacDonald & Co., Ltd., 37 Madison Ave., Room 220, New York 10, N. Y.* $5.75.

This book is written primarily for senior electrical engineering students and is something new in the way of an electrical machine design textbook. Since the book is British, American design engineers will find many of the illustrations unfamiliar and will find many problems approached from a slightly different angle than is customary in this country. However the book does give a good basic approach to the subject.

The work is the result of the author's years of practical experience as a designer of electrical machines, while the procedure and methods employed are those of the professional designer.

The general presentation of the method is in Metric Units, except in the case of certain details which are clearly indicated in the text. The book must naturally include much material common to other works on the same subject, but the large amount of detailed work required in the development of the various formulae has been omitted, while many curves calculated from the final formulae are included,

THE NATIONAL ELECTRIC COIL COMPANY'S
Induction heating coil for pinion pulling.

Insulated with OWENS-CORNING FIBERGLAS GLASS-BASE ELECTRICAL INSULATING MATERIALS

Insulated with OWENS-CORNING FIBERGLAS GLASS-BASE ELECTRICAL INSULATING MATERIALS

A DESIGN TO REMEMBER

*an example of the application of*

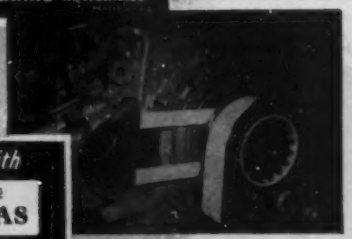
# electrical insulating materials

*made with*

# FIBERGLAS* *Yarns*

*to help achieve greater resistance to sustained high temperature*

Insulated with OWENS-CORNING FIBERGLAS GLASS-BASE ELECTRICAL INSULATING MATERIALS



Insulated with OWENS-CORNING FIBERGLAS GLASS-BASE ELECTRICAL INSULATING MATERIALS

*Fiberglas glass-base laminates . . . wire coverings and tapes made with Fiberglas yarns and silicones . . .* are all used to increase the service life, and service effectiveness, of this rugged induction heating coil.

National Electric Coil Company of Columbus, Ohio, was faced with this difficult design problem:

Create an induction heating coil that would raise the temperature of a steel pinion in 2 minutes to approximately 175° C., hot enough to pull easily. Coil must withstand heat generated in the coil itself by the very high wattage (132 KW) required, as well as the heat transmitted to it by the induction-heated pinion which the coil closely incloses. Build into this pinion-puller maximum service effectiveness and long life. Choose insulation that stands up under continued high temperatures.

National's design engineers provided the solution with the help of insulating materials made with Fiberglas yarns!

High thermal conductivity, plus resistance to moisture, corrosion, and rot are other basic properties of Fiberglas yarns. Remember them when insulating materials are an essential part of your product design.

***A new manual of Fiberglas glass-base insulating materials is available now. Send for your copy today.***

Owens-Corning Fiberglas Corporation
Textile Products Division, Dept. 807
16 East 56th Street, New York 22, N.Y.

OWENS-CORNING FIBERGLAS *Yarns*

*Fiberglas is the trade-mark (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for a variety of products made of or with glass fibers.

ELECTRIC WHEELS
Designed to do the Job
Wheels and Axles are our business, and our engineers are well qualified to recommend the most efficient assembly for your product.
Our factory is modern and tooled for low cost production. We have supplied manufacturers in many different industries for more than 50 years.
Standard or Special, ELECTRIC Spoke-type or Disc Wheels are built for most types of portable equipment.
Send us your specifications and we will submit our recommendations.
ELECTRIC WHEEL CO., 2910 Pine, Quincy, Ill.

ALLMETAL'S First Quality
STAINLESS STEEL FASTENERS
IMMEDIATE DELIVERY • ALL TYPES & SIZES
Made right . . .
Priced right . . .
by specialists in stainless!
See Allmetal first for stock shipments of stainless machine, set, self-tapping, wood screws, nuts, bolts, pins, washers, rivets, including Government and "AN" specs. Prompt delivery on various types of Phillips Recessed Head Screws and specials, too.
WRITE FOR CATALOG 49F
MANUFACTURERS SINCE 1929
ALLMETAL
Screw Products Co., Inc.
33 GREENE STREET, NEW YORK 13, N. Y.


examples of their use being given as the text progresses.

A completely calculated design is given both in the text and on a typical commercial design sheet. Five further examples are given on similar sheets, all of them having magnetic and electric loadings in line with what one obtains when employing well-designed air-cooling circuits.

A chapter dealing with mechanical construction, though not including the details of the design of the mechanical parts, has been considered desirable. The design of the fan (so often neglected) is, however, treated fully in an appendix, curves being included to facilitate design calculation.

## Grinding Practice

FRED H. COLVIN, *Editor Emeritus, American Machinist and* FRANK A. STANLEY, *formerly editor, Western Machinery and Steel World.* 418 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $3.75.

This completely revised book covers the field of grinding machines and abrasive wheels, showing what they do, how to operate them, how to make best use of them on various types of work, and the advantages in production economy that result from use of the right machines and methods.

Full of practical techniques and methods that are followed by leading shops in the country, the book brings you usable information on the use of diamond abrasive wheels—on wheels for cutting-off work, complete with details as to speeds, wheel selection, and wheel life—and on the use of small mounted wheels and abrasive points. It covers, in detail, precision grinding to millionths of an inch, the grading of diamond powder for lapping, and honing and surface finish, including superfinish by modern methods.

The design engineer will not find this book of primary interest to his main job. However, for those designers who feel the need of more knowledge in production techniques, the book will cover an important production phase.

## Facsimile

LEE HILLS *and* TIMOTHY J. SULLIVAN, *First Edition.* 6 x 9 *in.,* 319 *pages. Published by the McGraw-Hill Book Co., Inc.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $3.50.

This practical book covers every phase of the process of facsimile, tracing its growth step-by-step from infancy to its present status as a potential rival to conventional means of jour-

## SO REAL THEY REACH FOR THE BOTTLE

# —but it's KOPPERS POLYSTYRENE

These displays for Miller High Life Beer have been extremely successful in winning new customers at the point of sale. Molder: Anfinsen Plastic Molding, Inc., Aurora, Ill. Display maker: Thomas A. Schutz Co., Chicago, Ill.

Many a man has been tempted to reach for the bottle in this effective display for Miller High Life Beer . . . but the bottle, the ice and the bucket are all made from Koppers Polystyrene.

The back of the transparent bottle is sprayed with a pale amber color exactly the shade of the beer. Real labels are pasted on and the top is gilded.

The bucket looks like aluminum, but once again it's crystal polystyrene sprayed with metallic paint, however, the lettering is transparent, permitting vari-colored light to shine through.

Even the ice is transparent polystyrene, molded in a specially-finished mold which gives the realistic effect.

This display shows the variety of effects you can get with Koppers Transparent Polystyrene and the small display uses an eye-catching red polystyrene to get its share of attention.

A number of factors led to the choice of Koppers Polystyrene, but the main ones were these —

- **LOW COST**—Huge quantities of these displays were needed, so Koppers Polystyrene 3 was used to produce more finished pieces per pound and more per dollar.
- **EASY MOLDING**—Koppers Polystyrene 3 is easy to mold and easy to release from the mold—factors that resulted in more pieces per hour.
- **VERSATILITY**—The three main parts of the display—bottle, ice and bucket are all made from one plastic.
- **EASY TO PAINT**—Polystyrene can be painted to achieve many lasting and desirable color and depth effects.

**How you can reduce costs with Koppers Polystyrene**

Koppers Polystyrene is among the lowest in cost of all thermoplastics. Polystyrene 8 has a high heat distortion temperature — over 200°F. Polystyrene 3 is noted for its ease of molding and its fast molding cycle. Both types are available with internal and external lubrication. Our technical men will gladly help you with your plastics problems.

**KOPPERS COMPANY, INC.**
Chemical Division Pittsburgh 19, Pa.
Regional offices: New York, Boston, Philadelphia, Chicago, Detroit and Los Angeles

KOPPERS

Koppers Company, Inc.
Chemical Division, Dept. PE-3
Pittsburgh 19, Pa.

Please send me latest information on Koppers Perfected Plastics.

Name.....
Position.....
Company.....
Address.....
City.....State.....

**Koppers Perfected Plastics**

Sewall GEARS

CUSTOM MADE
For EVERY NEED

For best results, get in touch with Sewall engineers while your product is still on the drawing board. Close tolerances are efficiently maintained in the production of racks... sprockets... spur... spiral... bevel... Zerol bevel... worm gears. We furnish prompt estimates on any quantity.

E. B. SEWALL MANUFACTURING CO.
496 Glendale St. St. Paul 4, Minnesota.

"I'm Rugged! I'M MICRO-WEAVE TRACING CLOTH"

"Yes, sir, I can really take it! I can stand up under repeated erasures — hand or mechanical — and still take pencil smoothly *or* ink-over freely — *without* leaving 'ghost lines' — that's what I was made to do and that's *exactly what* I do — thanks to my finer, closer weave and unique surface."

MICRO-WEAVE Tracing Cloth exceeds all specifications in transparency — in minimum feathering — in maximum strength. Put it to any test on your drawing board and discover why it is first choice with so many draftsmen all over the country. Generous sample on request.

THE HOLLISTON MILLS, INC.
NORWOOD, MASS.
NEW YORK PHILADELPHIA CHICAGO

★ MICRO-WEAVE is backed by Holliston's 50 years of leadership and experience in developing special cloths for industry.


nalistic communication. It explains what facsimile is, how it works, and its immediate and potential commercial uses.

This material is drawn from the actual experience of publishing a five-edition daily facsimile newspaper. It describes facsimile uses for mass communications; as a military weapon; as a newspaper for sending telegrams, airline, police, school, railroad, bank, industrial and utility information, and as a recording instrument. It goes from early experiments in facsimile to its use in sending colored pictures or transmitting 1,000,000 words per minute.

The book discusses opportunities in facsimile for publishers, manufacturers and retailers. It describes, in laymen's terms, the needed equipment, and how it operates and includes a section dealing with teaching, because journalism schools are interested in adding this new subject to their curricula.

The book also provides a comprehensive explanation of facsimile, as well as FM broadcasting, microwave relay and other radio adjuncts to facsimile. At the same time it gives an insight into copy and photographic editing.

## The Alchemists

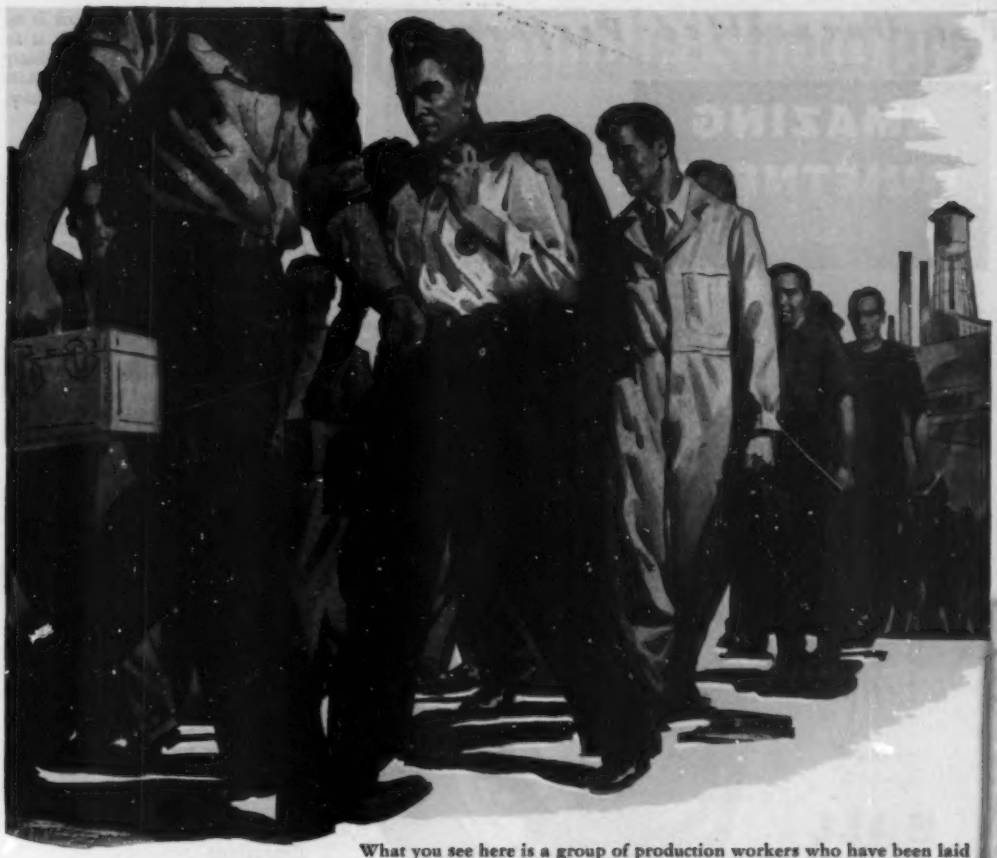
F. SHERWOOD TAYLOR, *Curator, Museum of the History of Science, Oxford, 242 pages, 6 x 9 in. Published by Henry Schuman, 20 E. 70th St., New York, N. Y.* $4.

The sub-title "Founders of Modern Chemistry," explains the general approach in this book. It will be of general interest to any reader who has a scientific background and a curosity.

Dr. F. Sherwood Taylor has established that the central idea of alchemy is the ancient notion that the activity of bodies is a subtle stuff, a breath of influence, intermediate between matter and mind. The development of such ideas enables him to resolve the apparent contradictions of alchemy, to show how it can be at once a craft and a creed, a quest for riches and a work of piety, a laboratory research and a mystical system.

Eighteen hundred years ago the alchemists began the long tradition of laboratory technique which has culminated in the triumphs of modern science. Their importance to its history is obvious, yet their writings have hitherto remained deeply obscure. Their picturesque symbolism of lion and dragon, toad and serpent has received no convincing interpretation.

This book draws upon the whole body of alchemical writings, including many unpublished manuscripts. A particularly unusual feature is its chapter



# STRIKE?

## no..they're out because of a broken bolt!

What you see here is a group of production workers who have been laid off temporarily—all because the fastenings on a vital piece of processing equipment were critically corroded.

What you can't see is the look on the plant manager's face when he calculates the cost of the work stoppage.

If the equipment *you* make is used by *your* customers in operations where corrosion is a factor . . . or where attractive appearance, long life, ease of cleaning and resistance to high temperatures are important . . . it will pay you to make sure every bolt, nut and rivet is non-ferrous or stainless steel.

Harper specializes in these Everlasting Fastenings; makes them in over 7,000 different sizes, types and alloys—Brass, Bronzes, Copper, Monel and Stainless Steels; maintains large quantities in stock, ready for immediate delivery.

*Write today for 134-page catalog* and current stock list. The H. M. Harper Company, 8203 Lehigh Avenue, Morton Grove, Illinois

**New York Office and Warehouse:** 200 Hudson St.
**Los Angeles Office and Warehouse:** 835 E. 31st St.
**Branch Offices:** Atlanta, Cambridge, Cincinnati, Cleveland, Dallas, Denver, Detroit, Grand Rapids, Milwaukee, Oakland, Philadelphia, Pittsburgh, St. Louis, Seattle, Toronto (Canada)

AMERICA'S LEADING SPECIALIST IN NON-FERROUS AND STAINLESS STEEL FASTENINGS

HARPER

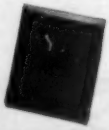
EVERLASTING FASTENINGS

*For Unexcelled Performance*

**HOOVER** *the only* **BALL BEARING** *with* **HONED RACEWAYS**

**Here are three pertinent reasons why you should consider Hoover Ball Bearings — with honed raceways. First, these bearings achieve unbelievable quietness. Second, they increase bearing life 90 per cent. Third they have a 30 per cent greater load capacity. When you specify Hoover Ball Bearings you secure these PLUS features without extra cost.**

*The Hoover Engineering Manual gives all the facts. Write for your copy.*



THE ARISTOCRAT OF BEARINGS

HOOVER BALL and BEARING CO.
*Ann Arbor, Michigan*

on Chinese alchemy. The book is no resume of published works. It is an important contribution to the history of science and thought, and more specifically to the history of chemistry.

## High Molecular Weight Organic Compounds

*Edited by* R. E. BURK, *Plastics Dept., E. I. duPont deNemours & Co. and* OLIVER GRUMMITT, *Morley Chemical Laboratory, Western Reserve University.* 6 x 9 *in.*, 330 *pages. Published by Interscience Publishers, Inc.*, 215 *Fourth Ave., New York* 3, *N. Y.* $5.50.

This book is Volume VI in a series entitled "Frontiers in Chemistry", published under the auspices of Western Reserve University. Although the contents of the volume are mainly chemical in nature, they should be of some interest to the engineer who has occasion to use plastic materials. Covered in this volume are various mechanisms of polymerization in suspension and emulsion. The nature of elastomers—flexible polymers—is given a thorough discussion. Of particular importance are the last two chapters, "Condensation Polymerization and Constitution of Condensation Polymers", and "Physical and Chemical Structure of Phenoplasts". These two chapters give specific data to show how and why thermoplastic and thermosetting resins behave the way they do.

## Designing with Aluminum Extrusions

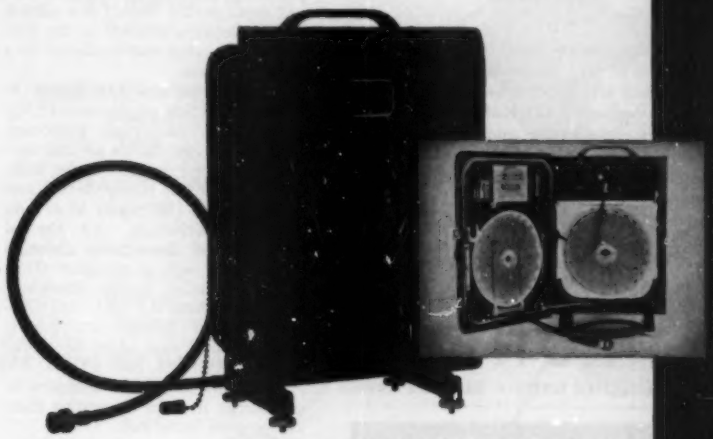
H. V. MENKING, *Assistant Director, Technical Service Dept., Reynolds Metal Co.* 138 *pages*, 6 x 9 *in. Published by Reynolds Metals Company*, 2500 *S. Third St., Louisville* 1, *Ky. No charge.*

This book sets forth the basic engineering principles that will enable the designer to use exruded aluminum shapes most effectively. The new book breaks down the advantages of the extrusion process into eight principles of design. Then each of these is illustrated and explained in detail by use of diagrams, charts and pictures of actual parts.

The section on examples of effective extrusion design contains more than 140 illustrations showing details of specific applications. The section on manufacturing possibilities explains the broad range of shapes that can be produced by the extrusion process. Another chapter correlates shape design with manufacturing limits and shows how many of these limitations can be offset by proper design. Since certain

# ...Hookup for trouble-shooters

Portable pressure gauges like this are used for testing and trouble-shooting. They must be easy to connect and disconnect quickly. The connecting tubing must remain tight despite severe and repeated flexing and abuse.



*Bristol Series 500 Recording Pressure Gauge fitted with American Flexible Metal Tubing, synthetic covered.*

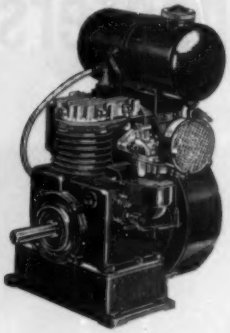
In this case, the American Flexible Metal Tubing carries the medium tested (gas, vapor or liquid), instead of serving as armor over capillary tubing. The illustrated full interlocked flexible metal tubing, synthetic covered, meets this complicated and difficult assignment with ease and assurance.

There is a style of American Flexible Metal Hose and American Seamless Flexible Metal Tubing to convey nearly every fluid or gas over widely varied conditions of temperature, pressure or mechanical stress. For full information, write to The American Brass Company, American Metal Hose Branch, Waterbury 20, Connecticut. In Canada, The Canadian Fairbanks-Morse Co., Ltd.

ANACONDA
from mine to consumer

**wherever connectors must move... *American***

**FLEXIBLE METAL HOSE AND TUBING**



Four-Cycle, Air-Cooled

# KOHLER ENGINES

*Compact • Quick-Starting Reliable*

Model K7-1, 1¼ H.P. 4-cycle, single cylinder, air-cooled. Length 15", width 14", height 17", Weight 38 lbs.

**POWER FOR:**
Farm Equipment
Garden Tractors
Water Pumps
Concrete Mixers
Construction Equipment
Conveyors
Rollers
Compressors
Sprayers
Motor Bikes
Scooters
And other uses.

Kohler Engines are designed, engineered and built to give the same dependable, economical service that has won world-wide acceptance for Kohler Electric Plants in construction and other industries. Made in several sizes, they are suited to a wide range of uses. Kohler engineers will gladly assist in working out applications for your particular requirements. Write for information. Dept. 15-V, Kohler Co., Kohler, Wisconsin. Established 1873.

## KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS • AIR-COOLED ENGINES

## HOW TWIN CITY REDUCES YOUR COSTS

Is your plant in the midwest industrial area? Our nearness means fast service and low freight costs. Our more than 30 years' experience producing high quality castings frequently means lower costs, too. And, by designing the proper die for your particular job, our capable engineers can often effect savings that may surprise you.

Our facilities include the most modern, high pressure equipment for precision production of zinc or aluminum die castings. We will give you advice and cost estimates without obligation. Write today for FREE BOOKLET: "Design Your Products for the Die Casting Process."

OLDEST DIE CASTER IN UPPER MIDWEST

CZ { Licensed Producer / Certified Zinc Die Casting plan

AMERICAN DIE CASTING INSTITUTE ADCI ACTIVE

TWIN CITY DIE CASTINGS COMPANY

Talmage & 33rd Aves., S. E.

Minneapolis 14, Minnesota


extruded shapes are used as structural or load-carrying members, a chapter is devoted to the principles of structural design.

One of the important features of extrusions is the ability to produce parts which interlock, using dovetail, contour, snap, or sliding fits for assembling parts together. A section on this subject illustrates the ease with which the designer can utilize this feature to advantage.

Because the extrusion process often permits elimination of machining by providing parts of exact dimensions and cross section desired, the dimensional tolerances inherent in the process are analyzed and explained in a separate section.

The characteristics of aluminum itself, the selection of the correct alloy and temper, fabricating properties, finishes, and cost factors are also covered as separate chapters in the book.

In addition, the tabular section presents 16 tables (22 pages) of data on chemical, mechanical, and physical properties of aluminum; extrusion process data such as minimum thicknesses, maximum lengths, tolerances, difficulty factors and the like. Condensations of finishes and joining methods form two tables of special value.

These handbooks are available without charge to those requesting them on company letterhead.

## Fifth Supplement to the ASTM Bibliography And Abstracts On Electrical Contacts

*Technical Publication No. 56-E, published by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. 24 pages, 6 x 9 in. Paper cover,* $.75.

The 1948 Supplement (issued 1949) to the Bibliography and Abstracts on Electrical Contacts is the fifth Supplement to the original Bibliography issued January 1944. This publication, including its Supplements, was compiled by a special group of technical leaders, in A.S.T.M. Committee B-4 on Electrical Heating, Resistance, and Related Alloys. The objective of this cooperated effort is to provide latest information on the subject to all concerned.

The 1948 Supplement includes a number of replacements and new references for the period 1940 through 1946 and much new material for 1947 and 1948.

The original Bibliography, 148 pages, cloth binding, is available at $5.00 each; the first and second Sup-

# THIS WIDE RANGE OF PUMPS MAKES SELECTION EASIER

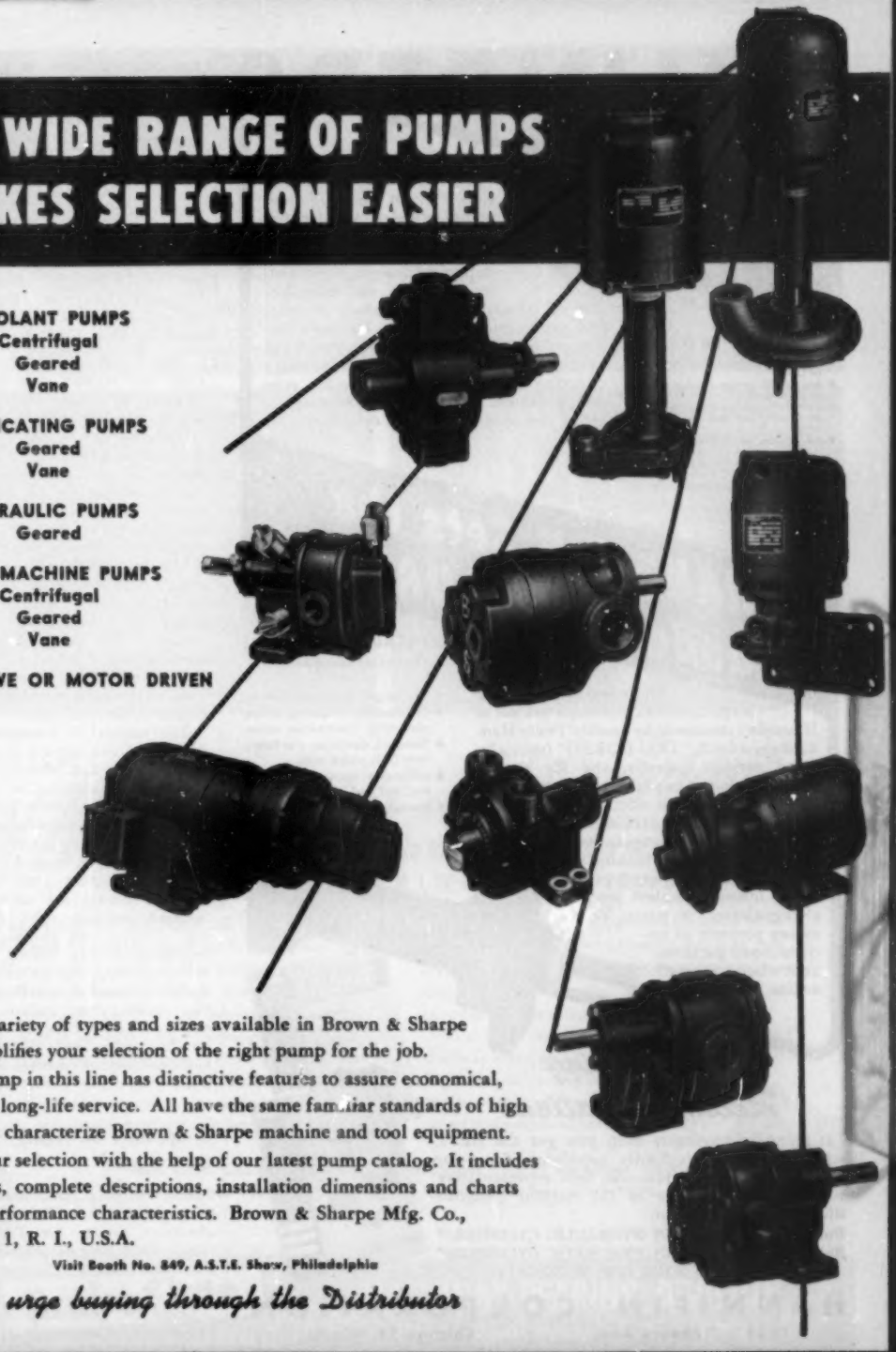
**COOLANT PUMPS**
Centrifugal
Geared
Vane

**LUBRICATING PUMPS**
Geared
Vane

**HYDRAULIC PUMPS**
Geared

**MISC. MACHINE PUMPS**
Centrifugal
Geared
Vane

**DIRECT DRIVE OR MOTOR DRIVEN**



The wide variety of types and sizes available in Brown & Sharpe Pumps simplifies your selection of the right pump for the job.

Every pump in this line has distinctive features to assure economical, dependable long-life service. All have the same familiar standards of high quality that characterize Brown & Sharpe machine and tool equipment.

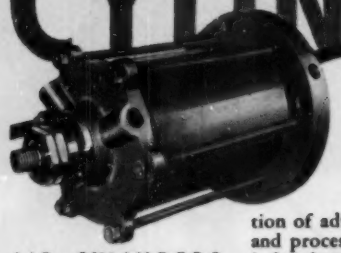
Make your selection with the help of our latest pump catalog. It includes illustrations, complete descriptions, installation dimensions and charts showing performance characteristics. Brown & Sharpe Mfg. Co., Providence 1, R. I., U.S.A.

Visit Booth No. 849, A.S.T.E. Show, Philadelphia

*We urge buying through the Distributor*

## BROWN & SHARPE PUMPS

# CYLINDERS



Continuous specialization since 1905 in the design and manufacture of cylinders has resulted in Hannifin leadership in the development of improved designs, use of better materials, and introduction of advanced manufacturing methods and processes. Collectively, Hannifin cylinders have chalked up literally hundreds of thousands of service years of experience covering almost every conceivable type of application. You are not experimenting when you specify Hannifin cylinders!

**AIR CYLINDERS**

- 10 standard bore diameters, 1" to 12".
- Any length stroke. Double acting or single acting.
- 6 basic mounting styles with many double end rod and combination styles.
- Adjustable cushions for head end, rod end, or both.
- Your choice of Series "LW" cup type or Series "R" externally adjustable "Leakproof" piston construction.
- Many special sizes, types available.

## HANNIFIN Sets the Standard for QUALITY!

There are easier, cheaper ways to build cylinders—*but not to Hannifin's standards for quality!* Every Hannifin cylinder is "TRU-BORED" (specially trued axially, laterally, and for roundness), then honed to a laboratory-controlled internal finish by exclusive Hannifin methods. Hannifin packings and seals are selected only after exhaustive tests. Hannifin designs and Hannifin's precision manufacturing processes insure complete interchangeability of parts. You assure yourself of unquestioned performance when you standardize on Hannifin!

**HYDRAULIC CYLINDERS**

- 12 standard bore diameters, 1" to 8".
- Any length stroke you specify.
- 11 standard mounting styles, plus many combination styles.
- Standard, double end, or heavy duty (2:1) piston rods.
- Adjustable cushions for head end, rod end, or both.
- Special sizes, types built to order.

## *Engineering Recommendations*

Let Hannifin engineers help you get the BEST solution for your cylinder problems. See your local factory-trained Hannifin field representative today. Ask for copies of the helpful bulletins illustrated at the right:

**Bulletin 110 "HANNIFIN HYDRAULIC CYLINDERS"**
**Bulletin 210 "HANNIFIN PNEUMATIC CYLINDERS"**
***SEND FOR YOUR COPIES TODAY!***

**HANNIFIN CORPORATION**
**1125 S. Kilbourn Ave. Chicago 24, Illinois**
AIR CYLINDERS • HYDRAULIC CYLINDERS • HYDRAULIC PRESSES
PNEUMATIC PRESSES • HYDRAULIC RIVETERS • AIR CONTROL VALVES


plements, combined, 48 pages, paper cover, at $1.50 each; the third Supplement, 26 pages, paper cover at 75 cents each; the fourth Supplement, 28 pages, paper cover, at 75 cents each. The Bibliography, with *all* Supplements, is $6.75.

### Manufacturing Analysis

RICHARD F. KIPERS, *Rochester Institute of Technology. First Edition. 452 pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y.* $5.

This new text is intended to familiarize the student with the various processes in tooling for the production of consumer and industrial goods.

The American Society of Tool Engineers made a financial grant to the Rochester Institute of Technology for the preparation of this work. The material was compiled from most recent information available and tried out in classes for a two-year period at the Institute. Local and national education committees of the American Society of Tool Engineers reviewed outlines of the manuscript from time to time. The combined efforts are intended to give a more complete coverage of the tool engineering functions in industry than has been evidenced in previous texts.

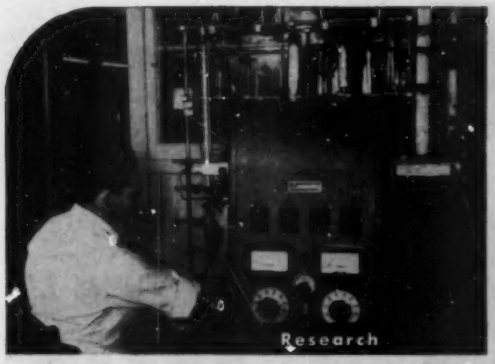
The material is presented so that the student will advance through progressive steps, first learning about the processes, equipment and techniques and then applying these principles to actual planning, analysis of operations, estimating, selecting machinery, equipment and tools to be used.

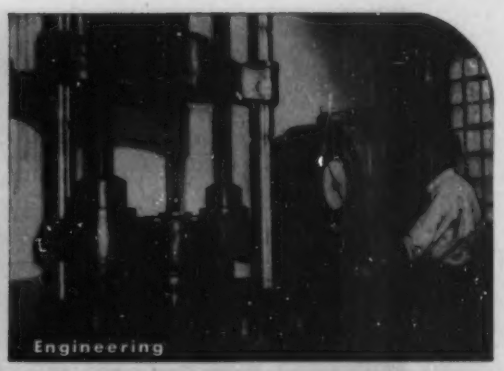
Various chapters cover such processes as forging, die casting, plastic molding, welding, press work, sawing, planing and shaping, milling, broaching, drilling, turning, grinding, thread forming, surface finishing, inspection, material handling, assemblies, tooling costs, analysis of operation and power balance. As a text on the college level, this book provides an adequate coverage of the subject.

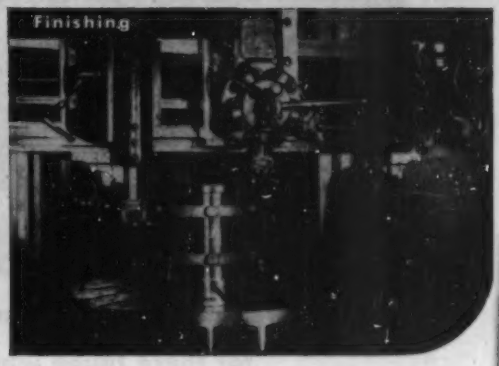
### Symposium on Aging Of Rubbers

*Special Technical Publication No. 89, 76 pages, 6 x 9 in. Published by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. Paper cover,* $1.75; *cloth binding,* $2.40.

Under the sponsorship of a special Symposium Committee in its Committee D-11 on Rubber and Rubber-Like Materials, the American Society for






**WHICH**

# *N.B.M. service is most important*

**FOR PRODUCING BETTER BRONZE BEARINGS AND CASTINGS?**

**The answer is that *ALL FOUR* are equally important... and ALL FOUR represent the reasons why more and more users of Non-Ferrous Bearings and Castings become N-B-M Customers.**

The complete facilities of National Bearing Division for Research, Engineering, Production and Finishing are unique. They represent an important *chain of service*—an ability to translate your *problems* into *requirements*, and requirements into *actual products* that serve you better.

The most modern equipment for alloy testing, molding, casting and finishing assures you of finer, more dense, closer-to-size bearings and castings—products that have higher resistance to wear and greater long-range economy.

Yes, this complete N-B-M Service is worthwhile investigating. Call in your nearest N-B-M Representative—he will gladly show you how this service can be geared to serve you with maximum efficiency.

**THIS NEW CATALOG completely describes N-B-M Facilities—how they can cut costs for you and tie in with your own production. Write for a free copy today.**

NBM

AMERICAN **Brake Shoe** COMPANY

**NATIONAL BEARING DIVISION**

4932 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST. LOUIS, MO. • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

LOOK Into BOUND BROOK

Graphited Bronze Bearings

for these tough jobs:

HOISTS • TRUCKS • CONVEYORS

PUMPS • BRIDGES • PLOWS

ELEVATORS • TRACTORS

BUSES • MACHINE TOOLS

*and many other heavy-duty, hard-to-lubricate jobs*

BOUND BROOK Graphited Bronze Bearings are built to withstand cold, heat, dust, mud, water and chemicals. Shafts turn freely, day in, day out, on a smooth thin film of graphite lubricant. Maintenance costs go down —service without maintenance goes up.

Cast bronze, inlaid with graphite.

CONSULT OUR ENGINEERS

BOUND BROOK "COMPO" "POWERON" BOUND BROOK


Testing Materials has issued a SYMPOSIUM ON AGING OF RUBBERS with six extensive papers by leading authorities. This Symposium gives an exhaustive review of the various methods for accelerating aging of natural rubber and synthetic elastomers. These tests are important because of their aid in predicting the life expectancy of finished articles.

The following papers comprise the Symposium: The Mode of Attack of Oxygen on Rubber; Oxygen—Absorption Methods—Their Utility and Limitations in the Study of Aging; Chemical Changes in Elastomers and Antioxidants During Aging; Physical Aspects of the Aging of Rubbers; The Effects of Light and Ozone on Rubber; and The Effect of Temperature on the Air Aring of Rubber Vulcanizates.

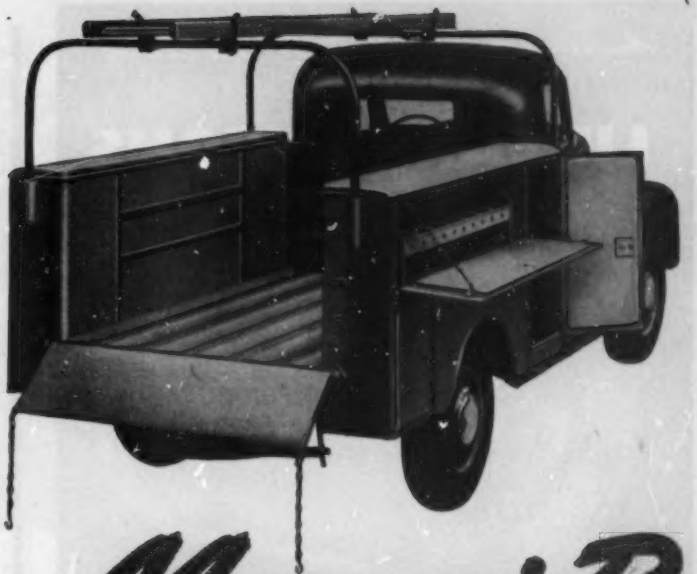
## Rewinding Small Motors

DANIEL H. BRAYMER *and* A. C. ROE, *Third Edition.* 6 x 9 *in.*, 422 *pages. Published by the McGraw-Hill Book Co., Inc.*, 330 *W.* 42*nd St., New York* 18, *N. Y.* $4.50.

Since there has been little practical information published on winding procedure for fractional-horsepower direct- and alternating-current motors, the authors have attempted to compile in this volume such details for all the common types of windings used for portable drills, grinders, automobile starting motors, sewing-machine motors, desk and ceiling fans, vacuum-cleaner and washing-machine motors, and other similar applications of small direct- and alternating-current motors. This information is presented in step-by-step details from the start to the finish of a winding job, to make it easy for the experienced winder to understand the procedure, to give him a grasp of the essential requirements of the windings that are used by the manufacturers of small motors, and to enable him to rewind or change them as conditions require, even though he may not have had much experience in rewinding small motors.

Small-motor rewinding jobs are, for the most part, simple, handwinding operations, but they call for the same good judgment and care as the rewinding of larger motors. In the commercial repair shop, to rewind small motors at a profit, in view of the low cost of the motor when new, a low labor cost is essential; and this calls for speed and a thorough knowledge of the kinds of windings used so that no errors will be found when the completed winding is tested out. There are some short cuts to be learned as well as steps in performing the work that will produce the quickest and most

# SERVICE TRUCKS WITH SALES APPEAL



## BUILT FROM *Mayari R*

Morrison Steel Products, Inc., of Buffalo, builds "Carry-All" truck bodies that have several important features made possible by Mayari R low-alloy, high-tensile steel. Though designed for general-utility use, these versatile bodies meet the many special transportation requirements of plumbers, electricians, carpenters, roofers and other tradesmen.

Using bridge-type underbody construction with Mayari R, these bodies have greater than average strength . . . Mayari R has almost double the yield point of plain carbon steel.

Deadweight has been trimmed to the minimum . . . Mayari R permitted reduction in thickness of 1 or 2 gages in all sections.

Weather has little effect on the body sections . . . Mayari R has 5 to 6 times the atmospheric corrosion-resistance of carbon steel.

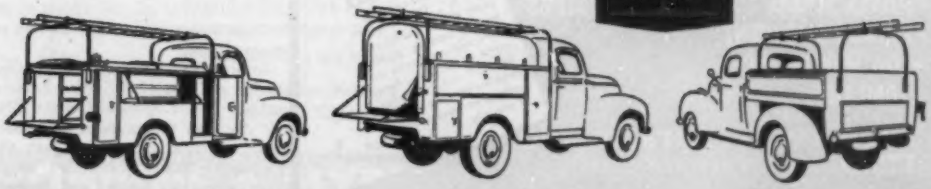
The finished bodies retain their clean appearance . . . because Mayari R has excellent resistance to denting and battering, and because paint lasts as much as 80 pct longer on Mayari R than on carbon steel.

Leading builders of trucks, trailers, buses, and many other types of vehicles are improving designs and increasing sales appeal through the use of this economical but superior grade of steel. For more information on Mayari R, its applications and properties, write for a copy of Catalog 259.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
*Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL



**Mayari R** *makes it lighter—stronger—longer lasting*

Announcing A New LOW COST Ball Bearing for Your

LINEAR MOTIONS

BALL BUSHING

THE COMMERCIAL GRADE SERIES B

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A Ball Bushing.

The low-cost Commercial Grade Series B bearing is now added to the Ball Bushing line and offered to original equipment manufacturers. This ball bearing has been developed for support of linear motions in competitively priced, volume produced products where super precision is not essential. Alert designers can now make tremendous improvements in their products by using Ball Bushings on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Competition is returning. Up-to-date engineering can be *important* to you!

- LOW FRICTION
- ELIMINATE BINDING AND CHATTER
- SOLVES SLIDING LUBRICATION PROBLEMS
- LASTING ALIGNMENT
- LOW MAINTENANCE
- LONG LIFE

NEW 1½" NOW AVAILABLE

Now in production for ½", ⅝", ¾", 1" and 1½" shaft diameters. If you have a catalog, phone your representative or write us for new Data Sheet. If not, write for complete literature and the name of our representative in your city.

THOMSON INDUSTRIES, INC.
Dept. F MANHASSET NEW YORK

PROGRESSIVE MANUFACTURERS USE BALL BUSHINGS — A MAJOR IMPROVEMENT AT A MINOR COST

satisfactory job from a workmanship standpoint. These factors have been taken into consideration in writing this book so that the practical side of the winding operations have been dealt with in detail, giving as little technical information as required to understand the reasons for the winding procedure that is presented.

This is a practical man's handbook on the winding of small direct- and alternating-current motors rather than a textbook on the subject. However, it will be found a useful reference book for those trade and manual training schools that conduct practical courses in motor winding.

This new edition includes information on Formex wire, glass insulated wire, glass insulation, silicon varnish, and combinations of glass and silicon-treated materials that will enable the repairman and engineer to increase the ratings and useful life of rewound motors, by such procedures as changing from Class A to Class B insulation. Thus hard-worked motors can be rewound to produce more usable horsepower with fewer burnouts.

## Lubrication of High-Speed Turbine Gear Equipment

*Symposium presented at A.S.T.M. meeting by Committee D-2 on Petroleum Products and Lubricants. Technical Publication No. 92, 6 x 9 in., 32 pages, paper cover. Published by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. 75 cents.*

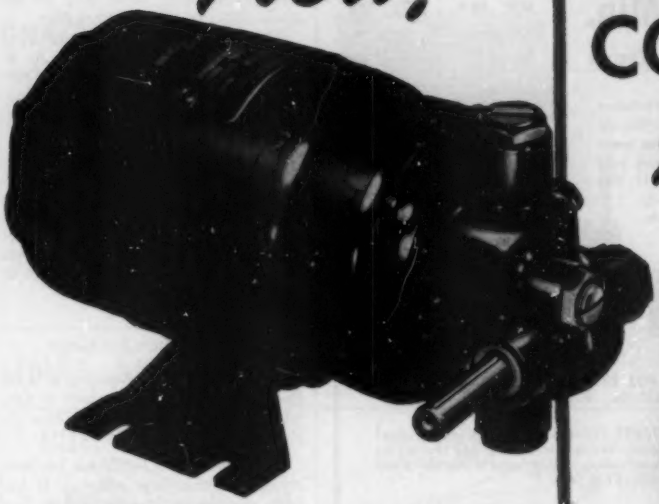
The publication includes four papers and an introduction, the latter by F. C. Linn of the General Electric Company, pointing out that the proper lubrication of turbine-driven gears and worm gears used in turbines is of vital importance to the manufacturer, the refiner and the customer.

The first paper, "Lubrication of Naval Gearing," is by R. T. Simpson of the Bureau of Ships. Some of the problems discussed are: Limitations of gear dimensions for a straight mineral lubricant; increasing the load-carrying capacity of the gears by use of higher viscosity oil for gear mesh lubrication; and thickness of oil film separating the teeth in a gear mesh under a given set of conditions.

In his paper "Developments in Gear Design and Their Lubrication Requirements," L. J. Collins of General Electric discusses the purpose of a lubricant; characteristics of a gear that operates without lubrication; importance of surface finish; and necessity of using lubricants of high viscosity.

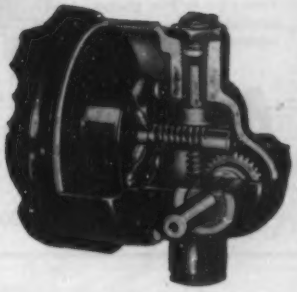
The paper, "Physical Concepts of the Establishment of the Lubrication

*New!*



**SIMPLE... COMPACT**

*Built to LAST!*



*NOW you can get*

# R & M PERFORMANCE IN GEAR HEAD MOTORS, TOO!

● Here's *good news* for designers of small power-operated equipment. Now you can get Robbins & Myers Gear Head Motors in *fractional-horsepower* ratings. You'll like their compact construction—neat appearance—*easy-to-use* convenience. And their on-the-job stamina means freedom from maintenance that *users* are sure to appreciate.

**SINGLE AND DOUBLE REDUCTIONS**
*(Ratings above 1/20 h. p. in Universal-Type Motors, only.)*
**MOTORS: 1/200 to ½ h. p.**
**COUNTERSHAFTS: 800 to 2 r. p. m.**
**TORQUE RATINGS: 1 to 6 in. lbs.**

*Write for literature, Address Dept. P-30*

These new units are functional—quality-built—with the *economies* of standardization. Motor ball bearings are double-sealed—require no lubricating in normal service for at least *five years*. Rotors are dynamically balanced for smooth and quiet operation. Worms are induction-hardened for *long-lasting* high wear value. Gears are precision-machined for uniform load distribution. From welded-steel motor shell to die-cast gear box, each element is typically "*Robbins & Myers.*"

Countershafts may project in any of several directions with respect to the base, for direct-connecting or other forms of power take-off. Motor types meet *every* service need. R & M Gear Head Motors are something *you* should know about now! Get all the facts today.

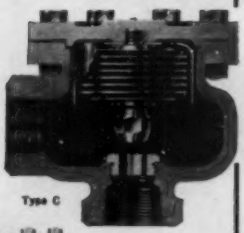
**ROBBINS & MYERS · INC.** MOTOR DIVISION
Springfield 99, Ohio • Brantford, Ontario

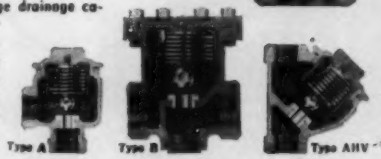
Leading Processor

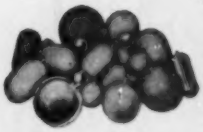
**SHORTENS OPERATION from 65 to 45 Min.**

With Nicholson Steam Traps

Records of a recent installation of Nicholson steam traps, by a large food packer, show they cut cooking time 30%; e.g., one operation was shortened from 65 to 45 min. Nicholson units keep equipment full of live steam because: 1) they operate on lowest temperature differential; 2) have 2 to 6 times average drainage capacity. Also record low for steam waste; and maximum air-venting capacity. Widely specified for preventing damage to thin gauges; eliminate cold blow in unit heaters.


Type C


Type A Type B Type AHV



5 TYPES FOR EVERY PURPOSE—Size ¼" to 2"; press. to 225 lbs. BULLETIN 1047.

HIGH-PRESSURE FLOATS — Stainless, monel, steel or plated steel. Welded. In all sizes and shapes; for operating mechanisms and as tanks or vessels. 2-day delivery. BULLETIN 348.

W. H. NICHOLSON & CO., 200 Oregon St., Wilkes-Barre, Pa.

**GRC's SMALLNESS UNLIMITED**

. . . THE BIGGEST THING IN TINY ZINC DIE CASTINGS

If your product or design calls for a really small part—call Gries, as so many cost-minded manufacturers do. Quickly and at amazing low prices, GRC's exclusive production facilities turn out simple or intricate parts in one automatic operation—completely trimmed, ready for use. 100,000 pieces to many millions. New design possibilities, new products, and substantial savings in many instances are now possible. See what GRC's smallness unlimited can mean for you.

Maximum Weight: ½ oz.
Maximum Length: 2 in.
NO MINIMUM!

*Write Today for Bulletin and Samples*

GRIES REPRODUCER CORP.
98 Willow Avenue, New York 54, N. Y.

Oil Wedge and Its Associated Load Carrying Capacity for the Mating Tooth Surfaces of High-Speed Gears," by Ernest K. Gatcombe, U. S. Naval Postgraduate School, places emphasis on the presentation of the physical concepts involved rather than on the mathematics of the subject matter.

The last article, "Fundamentals of Worm Gear Lubrication," by A. R. Purdy of the Socony-Vacuum Oil Company, deals only with surface galling, which is the broad term for wear, welding and seizure.

The authors have given a clear picture of the operating problems, the design problems and what has been accomplished in perfecting the gears and lubricating systems in bringing about the great improvements in geared sets and the possible improvements yet to be realized.

## Synthetic Rubber Packings

*Third Edition.* 110 *pages,* 6 x 9 *in. Published by E. F. Houghton & Co.,* 303 *W. Lehigh Ave., Philadelphia* 33, *Pa. No charge.*

This well-known handbook has been revised in this new edition. It has been completely brought up to date with the inclusion of packing standards approved by the Joint Industry Conference last year.

This handbook should clear many mysteries in the minds of design engineers as to proper application and use of synthetic packings. The book starts out with general information and classes and types of synthetic rubber packings. The next two chapters deal with the application and design of fabricated and homogeneous packings. Other chapters discuss leather back-up washers and "O" ring gaskets. A great deal of reference data has been included.

## Principles of Aerodynamics

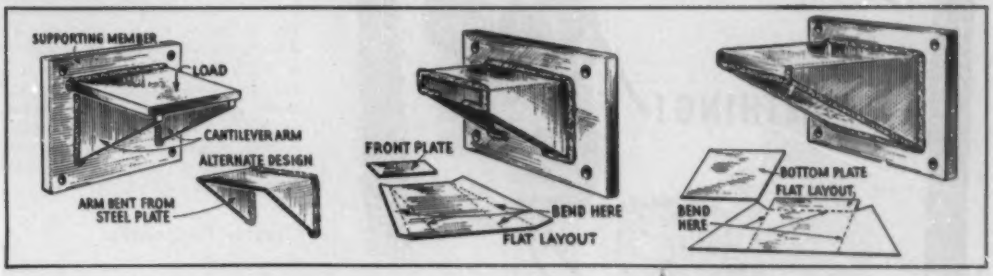
JAMES H. DWINNELL, *Assistant Professor of Aeronautical Engineering, University of Washington. First Edition.* 391 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co., Inc.,* 330 *W.* 42 *St., New York, N. Y.* $5.50.

An up-to-date introduction in theoretical and practical aspects of aerodynamics is presented in this undergraduate text. Considerable amounts of experimental data are included for comparison with theories, rather than for handbook use. It has been the author's objective to present a gradual development of aerodynamic principles and verification of these principles through recent test data.

There are up-to-date discussions on such topics as Reynold's Number ef-

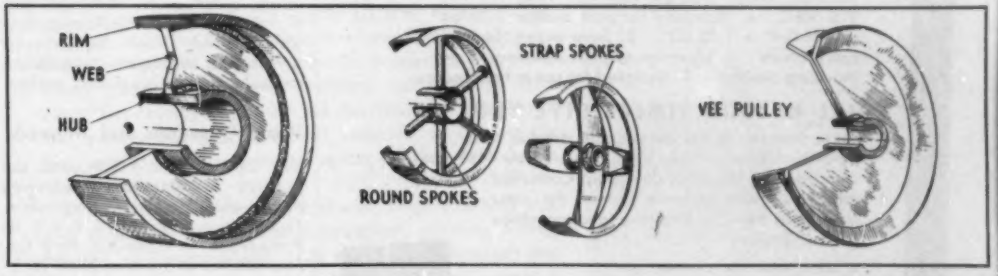
# Welded Design Builds These Parts Stronger and at Lower Cost

## BRACKETS




## LINKS AND CLEVICES

## WHEELS




BY designing component machinery parts for welded steel construction, manufacturers today are using less material, achieving greater strength, eliminating the need for patterns and thus are lowering their production costs. Many are following the simple approach to redesign of existing machinery by changing over one part at a time, assuring continuous production during reconversion.

In the production of welded steel machinery parts components are generally cut or sheared from plain steel shapes or from plate, then held in simple clamp-type fixtures and weld-assembled with fast, easy, down-hand techniques.


**THOUGHT STARTERS FOR MACHINE DESIGN**

*For free data sheets on welded machine design, write*

**THE LINCOLN ELECTRIC COMPANY**
**Dept. 31, Cleveland 1, Ohio**

*Sales Offices and Field Service Shops in All Principal Cities*

LINCOLN

# Timing Ideas

## DO SOMETHING!

That's what this versatile interval timer by Haydon® says when its buzzer sounds off. This audible signal — at cycle completion — sounds continuously until manually turned off. The unit is driven by a dependable Haydon synchronous motor; is built to give constant, efficient service over thousands of cycles.

**FEATURES? LOTS OF THEM!**

1. Many intervals available with a wide range of motor speeds and minor variations in design. 2. Optional buzzer for audible signal at completion of cycle; sounds continuously until manually turned off. 3. Load contact ratings: 10A, 250 VAC; 1/2 HP, 250 VAC. 4. Unusually compact design; 3-53/64" x 2-55/64" x 1-25/32". 5. Snap action device for quick break. 6. Operates at peak efficiency in any mounting position. 7. Designed for use in tight spaces.

**ALL HAYDON TIMERS GIVE YOU**

these features of the dependable Haydon motor Total enclosure — Very small size — Slow (450 rpm) rotor for long life, quiet operation—Controlled lubrication with separate systems for rotor and gear train — Mounting and operation in any position.

® TRADE MARK REG. U. S. PAT. OFF.

**For complete design and engineering specifications, write for catalog: Timing Motors No. 322 — Timers No. 323 — Clock Movements No. 324. Yours without obligation.**

**HAYDON AT TORRINGTON**

HEADQUARTERS FOR **TIMING**

**HAYDON Manufacturing Co., Inc.**

**3127 ELM STREET**

**TORRINGTON, CONNECTICUT**

SUBSIDIARY OF **GENERAL TIME** CORPORATION


fects on various bodies; subsonic, transonic and supersonic characteristics of aerodynamic bodies; theory of airfoil properties.

After the introduction to basic physical principles in this field, the author covers fluid dynamics, aeronautical nomenclature, experimental facilities, airfoil characteristics, aspect ratio and plan-form influences, viscosity phenomena, compressibility phenomena, the optimum airfoil, auxiliary lift devices, (which includes a discussion of flaps, slots, boundary layer controls and dive brakes), parasite drag and power consideration, aircraft engines, propellers and airplane performance. A final chapter covers stability and control. Many problems are included at the end of each chapter.

### Graphic Presentation Simplified

R. R. LUTZ. 202 *pages*, 6 x 9 *in. Published by Funk & Wagnalls Company*, 153 *East 24th St., New York, N. Y., in association with Modern Industry Magazine.* $4.

Engineers who find it necessary to present data in chart form, particularly to non-engineering groups, will find that this book offers many helpful suggestions.

The author has endeavored to present a practical guide that shows how to present facts in a simple visual form, how to use these charts, and how to analyze a problem and select the graph best suited to it.

Curve charts, bar charts, rate-of-change charts, column charts, circle charts, sector charts, statistical map, pictorial and other miscellaneous types are described. Final chapters cover preparation techniques, reproduction methods, and statistical data analysis.

### Pump Questions and Answers

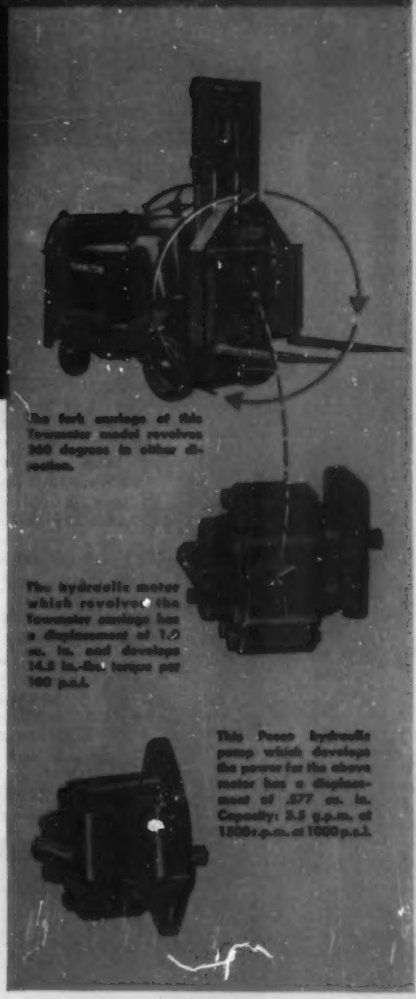
ROY CARTER, IGOR J. KARASSIK, and ELLIOTT F. WRIGHT, *Worthington Pump and Machinery Corporation. First Edition.* 346 *pages*, 6 x 9 *in. Published by McGraw-Hill Book Co., Inc.*, 330 *W. 42 St., New York, N. Y.* $5.

A group of engineers from Worthington Pump and Machinery Corp. have prepared this book to answer questions on the construction, application, operation, installation, maintenance and troubles encountered in pumps. The entire book is written in question and answer form to insure clear, concise presentation.

Five major sections, which deal with centrifugal pumps, vertical turbine pumps, regenerative pumps, rotary pumps and reciprocating pumps,

Pesco

# DUMPING MULTI-TON LOADS IN 5 SECONDS



The fork carriage of this Towmotor model revolves 360 degrees in either direction.

The hydraulic motor which revolves the Towmotor carriage has a displacement of 1.2 cu. in. and develops 14.8 in.-lbs. torque per 100 p.s.i.

This Pesco hydraulic pump which develops the power for the above motor has a displacement of .577 cu. in. Capacity: 3.5 g.p.m. at 1500 r.p.m. at 1000 p.s.i.

● One of industry's most effective material handling time-savers is Towmotor's fork lift truck with the revolving carriage. With it a man can quickly and easily transfer heavy loads of solid, liquid, or granular material from one container to another.

The ingenious device that revolves the fork carriage in a 360-degree circle, in either direction, is actuated by a Pesco hydraulic motor so small it will fit snugly into the palm of your hand. Yet it is so powerful it will flip loads up to three tons completely over in five seconds!

Towmotor is one of the rapidly growing number of industrial equipment manufacturers who are turning to Pesco for answers to their hydraulic problems. They have found that the skills and precision craftsmanship that Pesco has developed to meet the exacting requirements of the military and civilian aircraft manufacturers insure the high quality and trouble-free operation they demand in their own products.

Perhaps the sales power of hydraulic power can help you, too. If you have a problem in squeezing, gripping, lifting, holding, or turning heavy loads with precise accuracy and finger-tip control, why not let Pesco engineers suggest a solution.

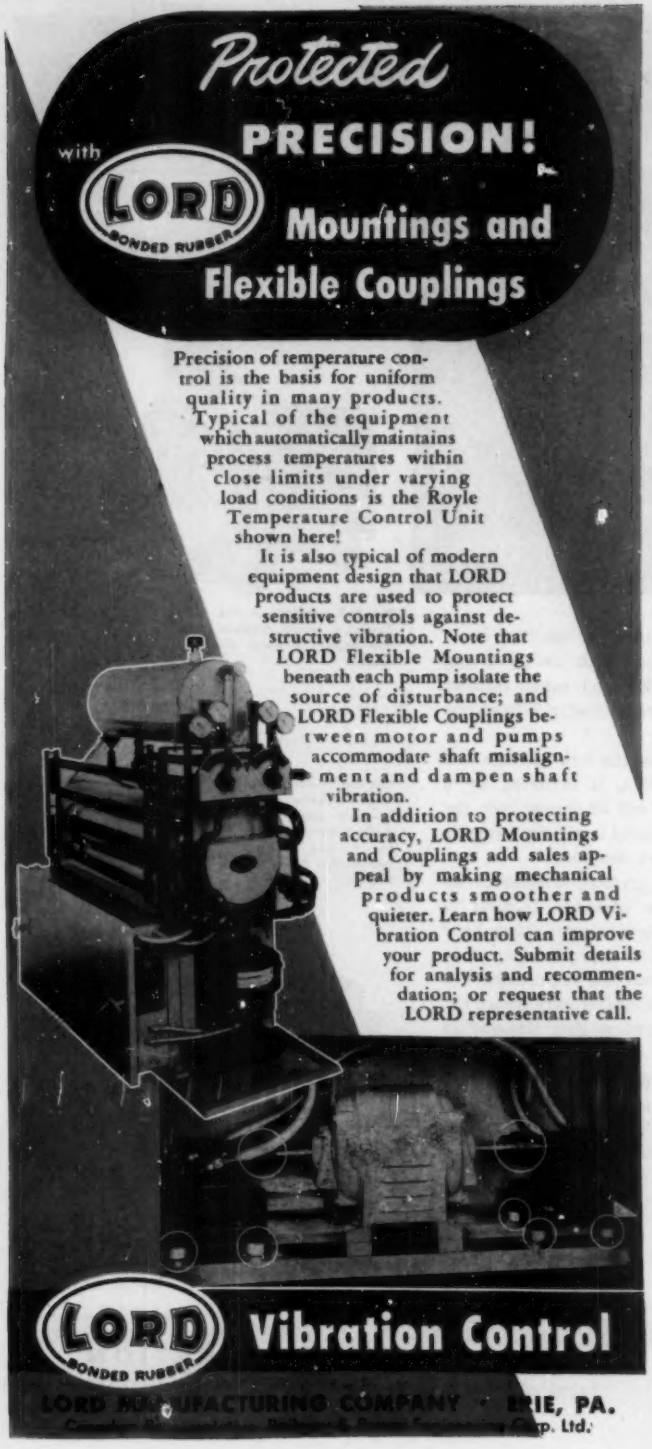
*A preliminary discussion will involve no obligation.*

engineering Pesco production

**PRODUCTS DIVISION**

**BORG-WARNER CORPORATION**

24700 NORTH MILES ROAD BEDFORD, OHIO


Protected
with
PRECISION!
LORD
BONDED RUBBER
Mountings and
Flexible Couplings
Precision of temperature control is the basis for uniform quality in many products. Typical of the equipment which automatically maintains process temperatures within close limits under varying load conditions is the Royle Temperature Control Unit shown here!
It is also typical of modern equipment design that LORD products are used to protect sensitive controls against destructive vibration. Note that LORD Flexible Mountings beneath each pump isolate the source of disturbance; and LORD Flexible Couplings between motor and pumps accommodate shaft misalignment and dampen shaft vibration.
In addition to protecting accuracy, LORD Mountings and Couplings add sales appeal by making mechanical products smoother and quieter. Learn how LORD Vibration Control can improve your product. Submit details for analysis and recommendation; or request that the LORD representative call.
LORD
BONDED RUBBER
Vibration Control
LORD MANUFACTURING COMPANY
ERIE, PA.

each open with a description of the pumps and their parts, as well as the various classifications under which they are usually subdivided. A discussion follows to analyze the operating characteristics and the application of each type of pump. Latter parts of each section deal with installation, operation and maintenance. It is definitely not a textbook. It ought to be extremely helpful in providing basic information and appreciation of pump types and their application, as well as their limitations.

## Lange's Handbook Of Chemistry

*Compiled and edited by* NORBERT ADOLPH LANGE, Ph.D., *assisted by* GORDON M. FORKER, *B.S. (Chem. Eng.), seventh edition. Published by Handbook Publishers, Inc., Sandusky, Ohio.* 5½ x 8 *in.*, 1934 *pages.* $7.00.

Despite its title, the new edition of this well-known handbook has a widespread appeal to engineering groups. A partial list of the topics covered—in addition to those of straight chemical interest—will give some indication of the broad subject matter: Dimensional formulas; metallic alloys; ceramics; wood; plastics; synthetic rubbers; wire tables; thermocouples; fuels; steam tables; humidity tables; and conversion factors.

Some of the tables not presented in the last edition, or completely rewritten, include: Table of isotopes; plastics and synthetic rubbers; corrosion and heat resistant alloys; commonly used ceramic materials; standard letter symbols and abbreviations; ASTM classification of coals by rank; dielectric constants.

This handbook will be particularly useful to the mechanical or design engineer whose problems are mainly in the field of materials.

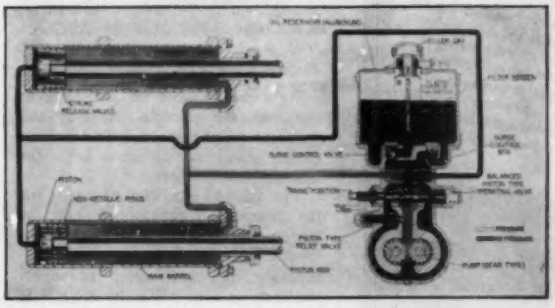
## Language in Thought and Action

S. I. HAYAKAWA, *in consultation with* BASIL H. PILLARD, *Antioch College.* 307 *pages,* 5½ x 8 *in. Published by Harcourt, Brace and Co., New York, N. Y.* $2.75.

Translating findings and conclusions into effective written form is an important function for many engineering jobs. Every engineer knows the frustrating feeling that comes with plowing through a long report in which the author has used five words where one would do, and where the exact meaning of the sentences and words is not clear. Those who are interested in improving their under-

# Good Equipment Made Still Better with LaPLANT-CHOATE HYDRAULIC UNITS

SPEED • POWER
VERSATILITY • SIMPLICITY
TROUBLE-FREE OPERATION



## Top Performance Built into Bros Dozers with LPC Hydraulic Units

FOR their *Power-Plus* Bulldozer, Bros engineers wanted speed and power for fast work under heavy loads . . . instant response to controls . . . simple, compact design . . . trouble-free operation. A complete LaPlant-Choate Hydraulic System consisting of jacks and the famous "packaged" hydraulic fluid power unit, was chosen to meet all requirements . . . to make their *good* product still *better*.

### Design Your Product for Better Performance

Whatever your problem, you'll get more efficient operation, simpler design and greater sales advantages for your product when you use LaPlant-Choate Hydraulic Units as standard equipment. Here are some of the features that will make your product better — *Compact Design* with pump, control valve, relief valve and reservoir contained in one simplified unit; *Versatile Application* on any type of machinery or equipment; *Multiple Use* of one installation with multiple valves, combinations and oil circuit variations; *Positive Fingertip Control* results in a high degree of operating accuracy and precision; *Easily Installed* and adaptable to a wide choice of mountings; *Low Maintenance* and *Long Life* under the most adverse operating conditions.

Write for complete information about making your products easier to design, manufacture, sell and service. Ask for Bulletin B-1152B LaPlant-Choate Manufacturing Co., Inc., Cedar Rapids, Iowa.

## THE LaPLANT-CHOATE FAMOUS FLUID POWER CONTROL

Pump, valve and oil reservoir are all combined into a single compact unit that mounts on the front of the tractor behind the radiator guard. This new "closed system" design completely eliminates long suction lines, reduces the hazard of leaks and assures greatly increased speed and efficiency. In addition, the entire unit is skillfully engineered and precision built for utmost simplicity, easy servicing, and long, trouble-free operation.

**LaPLANT CHOATE**

Cut Cost—
Add Strength
Your quantity-run special fastener type parts made
EXTRA FAST
by the Kaufman Process
Hold your costs down on out-standard headed and threaded parts. Many users are surprised at the economy and production speed possible, and the superior strength of most items when made by the Kaufman Process. Your specifications as to steel and heat treatment are carefully followed, or checked by our laboratory when desired. Send blue prints and specifications for estimate. The Cleveland Cap Screw Company, 2917 East 79th Street, Cleveland 4, Ohio.
CLEVELAND
Top Quality
FASTENERS
ORIGINATORS OF THE
KAUFMAN DOUBLE EXTRUSION PROCESS
Specialists for more than 30 years in
CAP SCREWS, SET SCREWS, MILLED STUDS
Ask your jobber for Cleveland Fasteners

standing of how words can be used accurately will appreciate this book by Dr. Hayakawa. In 1941, Dr. Hayakawa's book "Language in Action" sold 300,000 copies and was a Book-of-the-Month Club Selection. Since then, the text has been completely rewritten and more than half the present volume is new.

As a readable, practical demonstration of sematic principles in practical situations, this book is a good job. Each chapter includes a number of applications and examples that will emphasize the lessons behind the discussion. Typical chapter titles are: "The Language of Reports," "The Double Task of Language," "The Language of Social Control," "The Language of Effective Communication," "The Society Behind a Symbol."

The reader should not be misled into believing that this is a book on how to write reports. It is not. It is a discussion of the meaning of words. Read with this in mind, it will be helpful to those who want to improve their comprehension of our language.

## Electrical Estimating

RAY ASHLEY, *Electrical Engineering and Estimating Consultant.* 312 *pages,* 7 x 10 *in.* ***Published by McGraw-Hill Book Company, Inc.,*** 330 *W. 42nd St., New York, N. Y.* $6.50.

It is the purpose of this book to set forth the essential methods and practices of professional electrical estimating and to provide a basis for training new estimators.

This manual is written primarily for the contractor, estimator, engineer, or student who must solve complex problems of estimating, appraisal, cost accounting, job scheduling, or supervision as part of his daily affairs. It is closely concerned with the practical aspects of estimating such as the speed required to get out bids, the necessity for hewing close to the line in competition, and the personal problem of long hours over the board under the strain of large responsibilities.

Reflecting 25 years of experience in all branches of the electrical-contracting industry, this book covers everything from the selection and training of electrical estimators and the proper use of estimating tools, to the cost of preliminary estimates and the preparation of final bid sheets. Step-by-step it takes you through the design and use of estimating forms, the importance of weights and dimensions, meeting special estimating requirements, and estimating work of other trades.

It is full of practical information of value to the contractor, estimator and engineer.

# 1950 . . .
# *Our Industrial Machine Is Running Down*

**In his recent Economic Report to Congress President Truman chalked up a constructive advance in his economic reasoning. He pointed out that if we are going to attain the worth-while goal of a $300 billion national income in the next five years, we must equip ourselves with more and better industrial tools. Of all the dynamic forces of expansion in America, he said, one of the most important is business investment.**

That is fine. It is basic common sense. We have been saying that for years and we are glad to hear the President say it too.

But having hit this new high in his economic reasoning, the President failed to draw the right conclusion. He made the mistake of accepting the false conclusion that there is no shortage of business funds to pay for more and better industrial tools. "There are immense opportunities for business investment in nearly every segment of the economy," the President said, and further, "there are in general sufficient funds available to businessmen who want to seize these opportunities."

That just is not so — and the lack is not only serious; it can well be fatal.

It is a matter of the most urgent national importance that the President's recognition of the need of more and better industrial tools should be followed by effective action. *That calls for changes in the national policies that are now blocking and, unless changed, will increasingly block business from meeting this need. If business cannot get enough new tools, the result will not be higher, but lower standards of living five years from now.*

The President should talk this matter of business investment over with Senator O'Mahoney, the Chairman of the Joint Congressional Committee on the Economic Report. Senator O'Mahoney would take to the discussion knowledge of the investment situation recently acquired through his conduct of a series of Congressional hearings.

If he told the President what he told the press during the course of these hearings, he would say, "the private capitalistic system is being seriously threatened by a lack of venture capital." That is in direct conflict with the President's conclusion that "there are in general sufficient funds available."

**This serious shortage of adequate investment in new plant and equipment is brought forth so that all of us can understand it by McGraw-Hill's annual survey of American industry's plans for investment in new plant and equipment in 1950, which has just been completed.**

*continued on next page*

## BUSINESS' PLANS FOR 1950

These are the major findings of the McGraw-Hill survey of "Business' Plans for New Plants and Equipment" in 1950. Made by the McGraw-Hill Department of Economics, the survey shows:

1. Industry—as represented by manufacturing, mining, transportation, and utilities—now plans to invest $12.4 billion in new plants and equipment this year. This is 13% less than was actually spent last year.

2. Manufacturing industries alone plan to spend $6.3 billion in 1950 for new facilities. This is also 13% less than they spent last year.

3. Manufacturers as a whole expect their 1950 sales volume to about equal 1949's.

4. Manufacturers will expand their capacity about 3% in 1950, under present plans. The largest part of their funds, 65%, will go to replace and modernize existing facilities.

5. Profits and reserves are expected to provide 92% of the 1950 investment funds of manufacturing companies. These companies count on new common stock issues to provide less than one-half of one per cent of the investment funds they will need.

6. Two out of three manufacturing companies review their investment plans monthly. Almost all companies go over them at least quarterly. The survey shows that companies changed plans rapidly during 1949 to meet changes in their prospects.

7. Other industries are also reducing their investment plans in 1950 by 13%. This coincidence arises from the fact that utility companies, notably the electric light and power companies, plan to spend only slightly less than in 1949. Railroads, on the other hand, are reducing their capital programs in 1950 by more than 40%.

A copy of a complete report on "Business' Plans for New Plants and Equipment" may be obtained by writing me at McGraw-Hill Publishing Company, Inc., 330 West 42nd Street, New York 18, N. Y.

The results of the survey, which are summarized above, show that American Industry—as represented by manufacturing, mining, transportation and utilities—is planning to spend 13 per cent less for new plant and equipment in 1950 than it did in 1949.

Since the rate of investment in new plant and equipment right now is apparently about 15 per cent below the rate for 1949, the present level of business investment may be relatively steady in 1950. That would relieve the fear, expressed by President Truman in his Economic Report, that "if the downward trend in business investment were to continue, our prospects for full recovery and continued expansion would be seriously endangered."

*BUT, at the rate of investment planned by American manufacturing industry for 1950, it would take 40 years to modernize thoroughly our present industrial plant and equipment. That would still leave undone the job of increasing it to meet the needs of an expanding economy of the kind sketched by President Truman in his message.*

In attaining even this rate of investment, the McGraw-Hill survey shows American business must rely overwhelmingly on its own profits, which have declined as the country has left the postwar boom behind it. Most American companies cannot sell new common stock except at ruinously low prices. Here is one case where government action is really needed to help business and help to keep a rising American standard of living.

In order to get enough business investment to assure the "full recovery and continued expansion" sought by the President, our country needs:

**1. Lower taxes on business income so as to release more money for new plant and equipment.**

**2. Liberalized depreciation allowances on old plant and tools so that business can buy new equipment faster.**

**3. Repeal of the present double taxation of dividends which now are taxed once as corporation income and again as personal income.**

**It is encouraging to have the President explicitly recognize the key importance of adequate business investment in providing steadily expanding prosperity. The next and most important thing to do is to make this recognition effective by discarding national policies which are blighting an adequate volume of business investment.**

James H. McGraw, Jr.

*President, McGraw-Hill Publishing Company, Inc.*

# Westinghouse stops rust on switchgear housings

### All-weather 3M coating system protects metal against corrosion

Westinghouse outdoor switchgear housings need protection against rain, snow *and* abrasion from wind-blown sand and grit. Tough EC-1034 gives a rubberized coating that stays on the job in all kinds of weather —cold or hot.

You can solve *your* rust-prevention problems with one of the many 3M Coating Systems. There's one for every purpose. When you want to save money with a coating that's tailored to your needs, just remember the 3M name!

**SPRAYING HEAVY COAT** of EC-1034 on underside of switchgear cabinets at Westinghouse. Coating has excellent adhesion, forms a continuous, corrosion combatting film that won't sag—even at ⅛-inch thickness on a vertical surface.

**OTHER TYPICAL PROTECTIVE COATINGS**

**EC-244**—resists corrosion AND abrasion.

**EC-539**—Neoprene coating resists strong acids.

**EC-968**—vinyl coating protects polished metal in cold forming.

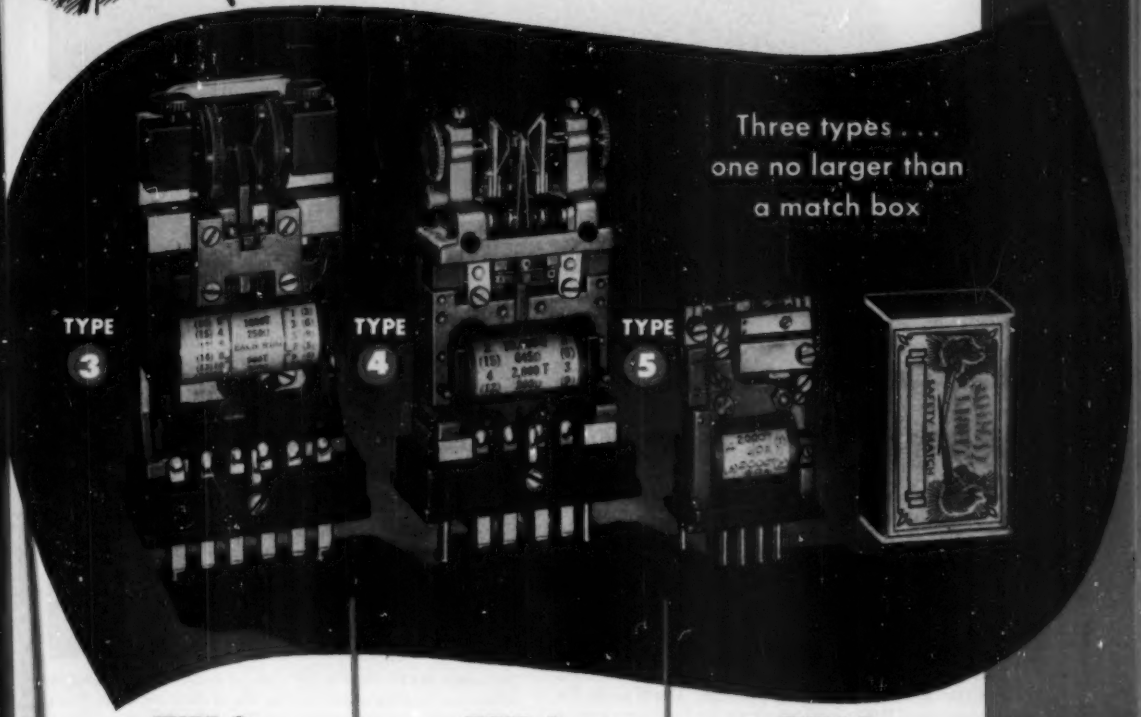
**Core-Gard**—protects against sour crude oil, fresh and salt water.

**WRITE TODAY** for complete information on the various metal-coating systems. Address: Adhesives and Coatings Division, 411 Piquette Avenue, Detroit 2, Michigan. Experienced engineers will be glad to show you how to cut replacement costs with these carefully formulated coatings. No obligation.

Made in U.S.A. by MINNESOTA MINING & MFG. CO.
ADHESIVES AND COATINGS DIVISION
411 Piquette Avenue, Detroit 2, Michigan
Also makers in St. Paul 6, Minn., of "Scotch" Brand Pressure-sensitive Tapes, "Scotch" Sound Recording Tape, "Underseal" Rubberized Coating, "Scotch-lite" Reflective Sheeting, "Safety-Walk" Non-Slip Surfacing, "3M" Abrasives.

*General Export:* Durex Abrasives Corp., *New Rochelle, N. Y.* • *In Canada:* Canadian Durex Abrasives, Ltd., *Brantford, Ontario*

# Available Now!




## TYPE 3

Maximum speed, contact pressure, and sensitivity; and minimum transit time. Originally designed as a high-speed telegraph relay, it has also been used for direct operation from barrier-layer photo cells and thermocouples, as well as for measurement and other industrial applications. Weight, 22 oz.

## TYPE 4

Long contact travel, medium speed and sensitivity. Originally designed as a telephone impulsing relay (d-c dialling up to 100 miles, and v-f dialling on trunk circuits), it has also been used in audio-frequency tele-printer systems, etc. Also available in d.p.d.t. version, with self-synchronizing contacts. Weight, 11.8 oz.

## TYPE 5

Miniature relay of phenomenal performance in proportion to size and weight. Primarily developed for military and aircraft uses, but is providing answers to problems in many other fields. Rugged design of exceptional thermo stability. Dimensions of relay proper same as safety-match box. Weight, 4.8 oz.

# CLARE RELAYS

# . . . A POLARIZED RELAY Far in Advance of the Field!

## C. P. CLARE & CO., secures U. S. rights to bring you the English-made CARPENTER POLARIZED RELAY

In recognition of a widespread need for a polarized relay capable of repeating with high accuracy feeble signal pulses of varying time duration and of maintaining this ability for long periods without attention, C. P. CLARE & CO. set out to design such a relay, to have the following characteristics:

- High sensitivity
- Low hysteresis
- Short transit time
- Complete absence of contact rebound
- Ease of adjustment
- Long operational life between adjustments
- High contact pressure
- Absence of pivots, with their almost inevitable shake and liability to wear or bind
- Immunity from the effects of mechanical vibration
- Absence of positional error
- Immunity from the effects of external fields
- Shortness of operating time — important for some applications

A comprehensive survey of available relays, made as a prelude to this design project, disclosed that the CARPENTER POLARIZED RELAY, manufactured by Telephone Manufacturing Co. Ltd., of London, England, conforms closely to the ideal and surpasses all previously existing polarized relays.

That this superior relay might be made immediately available to its customers, C. P. CLARE & CO. have paid a high compliment to another relay manufacturer: they have arranged to be exclusive distributor of the CARPENTER POLARIZED RELAY in the United States.

Some of the remarkable features of the CARPENTER POLARIZED RELAY which make C. P. CLARE & CO. proud to sponsor it are described on these pages. More complete information is immediately available from CLARE sales engineers located in principal cities. Look in your classified telephone directory . . . or write: C. P. CLARE & CO., 4719 West Sunnyside Avenue, Chicago 30, Ill.

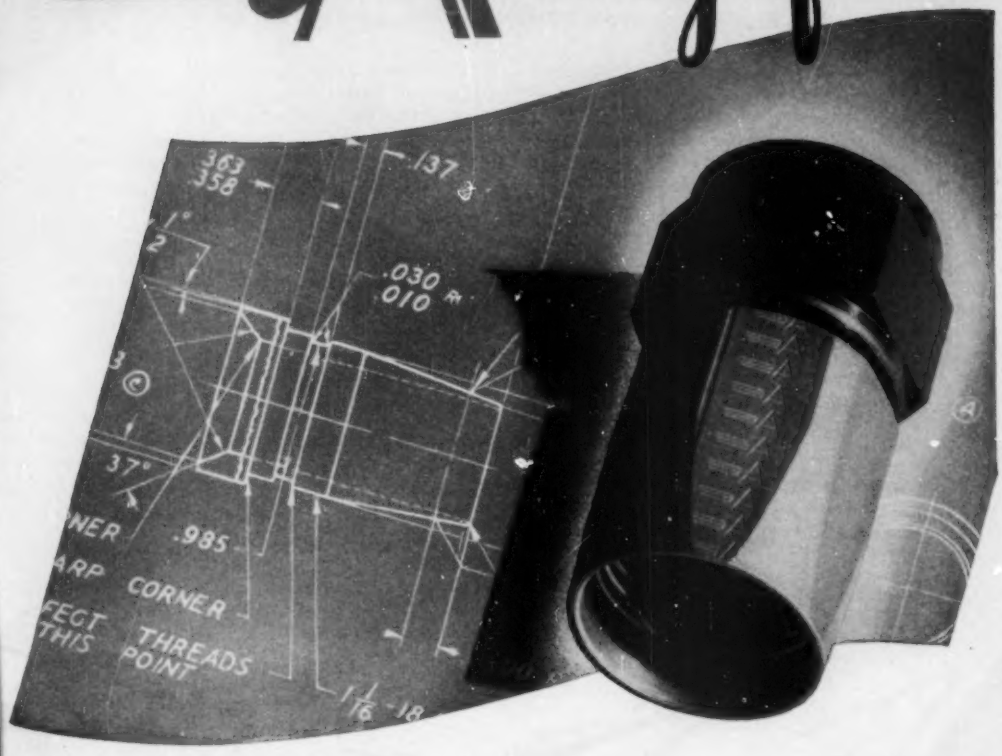
**Write for CLARE Bulletins 110-111-112 for complete details**

**MAGNETIC CIRCUIT OF TYPE 5 RELAY**

This schematic diagram shows the magnetic circuit of the Carpenter Type 5 Relay in one plane. Actually the axis of vibration of the armature is parallel to the axis of the signal coil. The working pole pieces (the S poles) of the permanent magnets and the contact mounts overlap one another on either side of the armature. The reversal circuit is reduced to its simplest possible form, having only a single air gap in which the armature is situated.

# . . . First in the Industrial Field

# Always first




Conceived FIRST, developed FIRST, produced FIRST. **This is the undeniable record of AEROQUIP DETACHABLE, REUSABLE HOSE FITTINGS. Industry was quick to accept this new and original "Aeroquip Idea." Not only did industry adopt the "Aeroquip Idea," other manufacturers jumped headlong into the manufacture of products they hoped to substitute for Aeroquip Fittings. Imitation is the best form of flattery, but Aeroquip design and quality have never been equalled.**

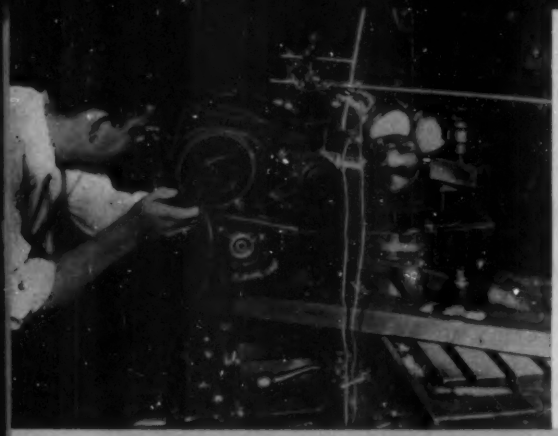
## AEROQUIP CORPORATION

JACKSON, MICHIGAN

**SALES OFFICES AND WAREHOUSES:** 1053 NO. HOLLYWOOD WAY, BURBANK, CALIF. 1215 SO. EAST GRAND AVE., PORTLAND 14, ORE. 2912 N. E. 28TH ST., FORT WORTH 11, TEXAS 72-74 STAFFORD STREET, TORONTO, CANADA

**SALES OFFICES:** 303 WAREHAM BLDG., HAGERSTOWN, MD. 1419 2ND AVE., SO., MINNEAPOLIS 4, MINN.

**AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U. S. A. AND ABROAD**



**IT HELPS IMPROVE PRODUCTS**—High speed movies provide a record of motion far too fast to see. With the Kodak High Speed Camera, a second becomes three minutes, so you can see and analyze rapid movement—spot faulty action and points of excessive wear—see ways to make a better product.

**IT COPIES DATA IN SECONDS**—Engineering drawings, shop orders, specifications, records, and letters of all kinds can be copied fast, and with utmost accuracy. Photocopying with Kodagraph Papers, Cloths, and Film saves time, protects originals from wear and tear—even permits producing clean, legible copies from faded or worn material.

# How photography's *Lightning Speed* works for business

HERE YOU SEE a few examples of how the speed of photography serves industry. In addition, its accuracy is used in copying drawings, documents, and data of all kinds. Its ability to reduce can put records on microfilm and save 98% of filing space.

These and the other unique qualities of photography are helping cut costs, improve products, speed production, and stimulate sales. If you would like to know more about how it could serve you, write for literature or for specific information which may be helpful to you. Eastman Kodak Company, Rochester 4, N. Y.

**FUNCTIONAL PHOTOGRAPHY**

**—serves industrial, commercial, scientific progress**

**IT ANALYZES CHEMICALS IN A FLASH**—Spectrography with Kodak Spectrum Analysis Film and Plates quickly determines the composition of almost all materials. It provides a means to make frequent production-line analyses. It can maintain a check on specifications and speed up output.

**IT RECORDS THE FLICK OF INSTRUMENTS**—The swift swing of the galvanometer mirror or cathode-ray tube beam is not too fast for photography. Readings of these instruments are quickly recorded on Kodak Linagraph Films and Papers so that they can be studied and full advantage taken of the facts that they reveal.

# RIGHT DOWN THE LIST—dump body builders specify BLOOD BROTHERS Universal Joints . . .

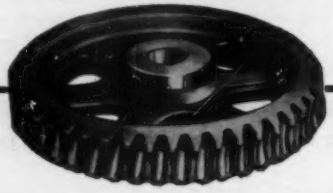
Anthony Company
Daybrook Hydraulic Corp.
Gar Wood Industries, Inc.
Hercules Steel Products Corp.
Marion Metal Products Co.
The Perfection Steel Body Co.
St. Paul Division, Gar Wood Industries, Inc.
The Heil Company

All these prominent manufacturers build dump bodies. And all build for strength, dependability and economy. That's why it's significant that each one specifies Blood Brothers Universal Joints to transmit engine power through an angle to hydraulic pump.

On many other products too, where designers aim for stamina and strength, Blood Brothers Universal Joints play a vital part.

They're engineered from long experience . . . built with the most modern facilities . . . and backed by a reputation for service and performance. For details, write for our complete catalog.

**BLOOD BROTHERS machine co.**
*A Division of Standard Steel Spring Co.*
ALLEGAN, MICHIGAN
Chicago Office: 122 S. Michigan



**MANY WORM WHEEL BLANKS for PHILLIE GEAR ARE CAST BY US**

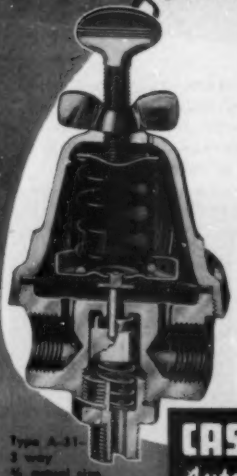
. . . and have been for years: further, we've had the privilege of supplying our HY-TEN-SL Bronze No. 1 for use in the widely known "Limitorque" Automatic Valve Operators, also made by Philadelphia Gear Works.

Should you have a problem involving the use of Bronze for Great Strength, Corrosion-resistance or unusual Wear-resistance—get in touch with us . . . no doubt our Engineers can help you.

**AMERICAN MANGANESE BRONZE COMPANY**

4705 RHAWN ST., HOLMESBURG, PHILADELPHIA 36, PA.
Pittsburgh, Pa. *41 YEARS' EXPERIENCE*

**FULL *fluid flow!***



Complete information on the FULL LINE of Cash-Acme Automatic Valves is yours for the asking. Send for Catalog D12. Pressure regulation in a small unit is available in Type A-31, illustrated here—a precision made Reducing and Regulating Valve for air . . . water . . . gas, etc.

Type A-31-3 way ¾ actual size.

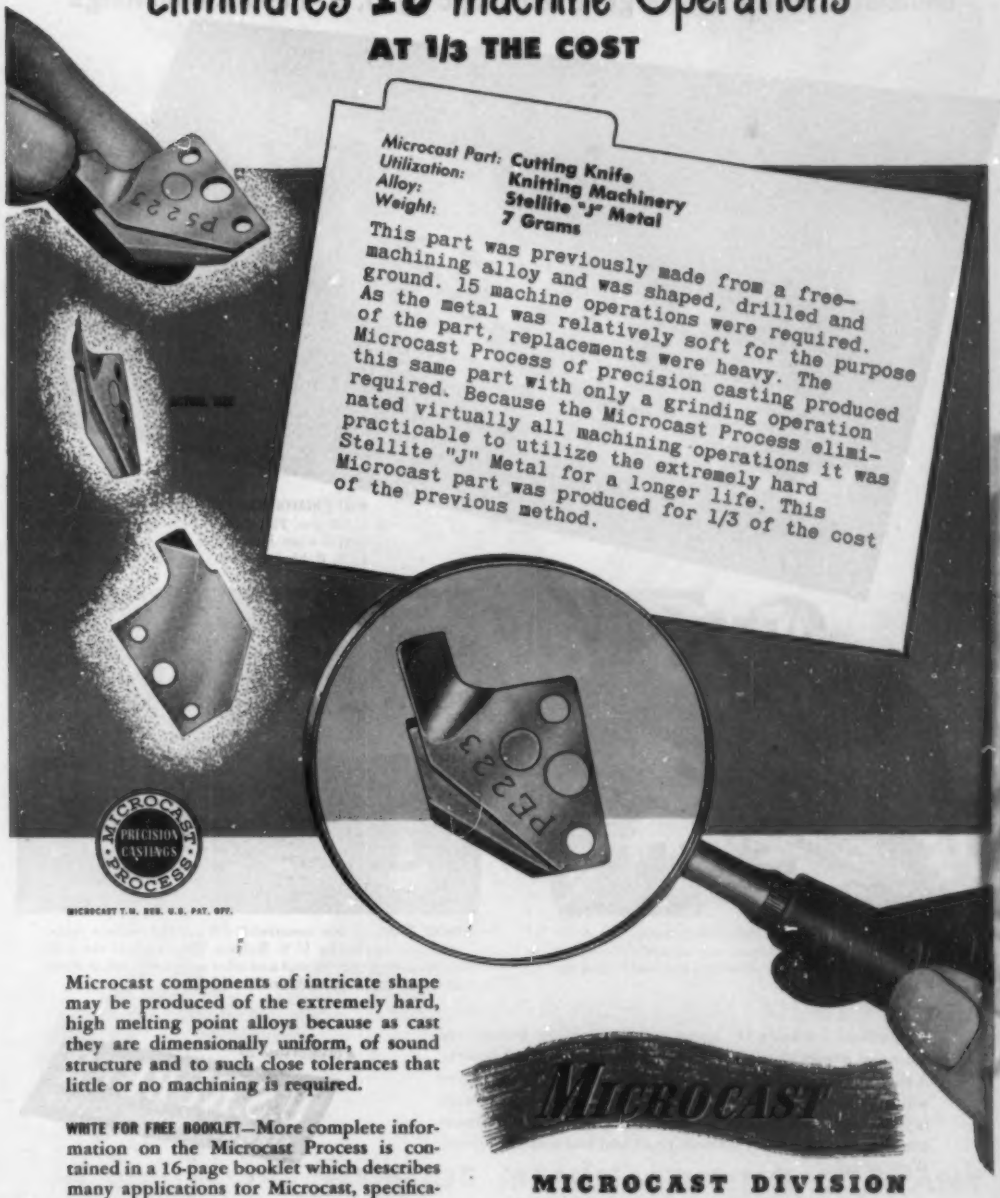
**CASH-ACME *Automatic Valves***

A. W. CASH VALVE MANUFACTURING CORP.
6662 EAST WABASH AVENUE DECATUR, ILLINOIS, U. S. A.

# MICROCASTING

## Eliminates 15 machine Operations

### AT 1/3 THE COST




*Microcast Part:* **Cutting Knife**
*Utilization:* **Knitting Machinery**
*Alloy:* **Stellite "J" Metal**
*Weight:* **7 Grams**

This part was previously made from a free-machining alloy and was shaped, drilled and ground. 15 machine operations were required. As the metal was relatively soft for the purpose of the part, replacements were heavy. The Microcast Process of precision casting produced this same part with only a grinding operation required. Because the Microcast Process eliminated virtually all machining operations it was practicable to utilize the extremely hard Stellite "J" Metal for a longer life. This Microcast part was produced for 1/3 of the cost of the previous method.

MICROCAST T. M. REG. U.S. PAT. OFF.

**Microcast components of intricate shape may be produced of the extremely hard, high melting point alloys because as cast they are dimensionally uniform, of sound structure and to such close tolerances that little or no machining is required.**

**WRITE FOR FREE BOOKLET**—More complete information on the Microcast Process is contained in a 16-page booklet which describes many applications for Microcast, specifications and a step-by-step explanation of the process itself. Write for this valuable booklet today!

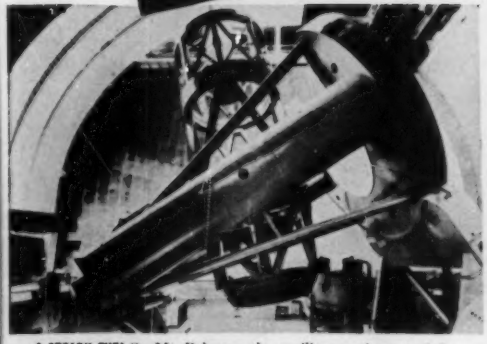
MICROCAST

**MICROCAST DIVISION**
**AUSTENAL LABORATORIES, INC.**
224 East 39th Street • New York 16, New York
715 East 69th Place • Chicago 37, Illinois

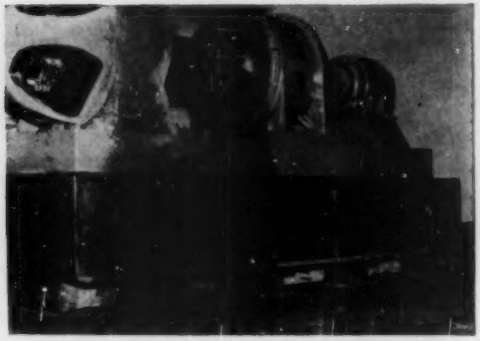
# HOW THEY MAKE THE STARS STAND STILL

## Blurred and restless images due to vibration eliminated in world's largest telescope by U. S. Rubber Mountings

**WHAT'S HEAVEN REALLY LIKE?** It takes a steady mirror to tell you. The slightest deviation causes great distortion when dealing with light-years. So that's why U. S. Rubber Company engineers were needed.



**A STEADY EYE!** On Mt. Palomar, the auxiliary equipment of the world's largest telescope (weight: one million pounds) does not transmit more than 1/10,000th of an inch in vibration, thanks to U. S. Rubber Mountings.



**INSIDE STORY** on this remarkable job are the resilient rubber cushions installed by U. S. Rubber. These support the dome drive motor generator unit and other equipment, act as shock-absorbers for all perceptible vibration.

No problem involving the absorption of vibration, transmitted noise and impact shock is too unusual for U. S. Rubber experts. A glimpse at the unparalleled research laboratories in Fort Wayne will show you why. Our free brochure explaining this laboratory is yours for the asking. Consultation with U. S. Rubber engineers may mean the difference between profit and loss in your business. Write or call

A DEVELOPMENT OF

U.S.RUBBER
SERVING THROUGH SCIENCE

**UNITED STATES RUBBER COMPANY**

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

mind if we blow someone else's horn?

SEYMOUR NICKEL SILVER skillfully used in the form of stampings, spun parts, milled and screw machine products, adds measurably to the quality of superb instruments like this. If quality is the keynote of your product, in your own interest, consider the use of

SEYMOUR NICKEL SILVER

Write for catalog.

THE SEYMOUR MANUFACTURING COMPANY

SEYMOUR, CONNECTICUT

Do you spend your time designing and producing parts for the aircraft, rubber goods, textile, bus, automotive, pneumatic tool, implement markets? ....or any other industry requiring a light casting?....You can be sure a light casting is the *right* casting if it's Well-Cast.

We have been hard at the business of producing high quality castings for 40 years: real economy results from the use of Well-Cast aluminum, magnesium or bronze castings: minimum rejects come out of our plants; we are in dead earnest about giving you good service; our facilities are complete.

Let's hear from you .... tell us your problem and we'll tell you whether a light casting is the right casting.

We *know* it will be if it's Well-Cast ... in sand, semi-permanent, permanent mold.

Catalog No. 50 on request.

**WELL-MADE WOOD AND METAL PATTERNS**

**THE WELLMAN BRONZE & ALUMINUM COMPANY**

*GENERAL OFFICES:* 2519 EAST 93rd STREET
CLEVELAND 3, OHIO

CASTINGS X-RAY INSPECTED

DO NOT DISTURB
for years and years
Double row width. Large area for housing contact
Good shaft shoulders and face.
Inside and outside metal supported seal.
Superior dust excluding and grease retention contacts.
Factory grease packed. Large grease capacity. Breathing and grease expansion space.
Standard load capacity.

Have you noticed? Something's missing from a lot of the new streamlined machines and equipment. They don't bulge at the ends. They're not studded over with bolt heads, screw plugs and oil cups. No arrows and lettering, "Oil here" or "Grease every 30 days". Look a little closer and you'll see something else missing that's even more important... a lot of costly machining operations. What happened? It's a new kind of ball bearing!

## It's a WRAP-UP!

This Fafnir Wide-Type Plya-Seal Ball Bearing looks like any other ball bearing. The difference is all *inside*. It has its own grease chamber, big enough for a years ahead supply of grease plus room for "breathing" and grease expansion. That obsoletes fill plugs, drain plugs, baffles, washers, covers and other gimmicks. Lubricant is sealed in at the factory, protected against leakage and contamination by Plya-Seals which tests prove the most efficient sealing device yet developed. Result: attention-free operation for years and years.

First to adopt this design-simplifying idea were electric motor manufacturers, followed closely by makers of drafting machines, water pumps, clutches, washing machines, generators, motor governors, textile machinery and other equipment that could use production savings and a new competitive edge.

## A NEW LOOK at old problems

We'd like to see you use these bearings but, even more, we'd like to get over to you the simple fact that Fafnir's principal function is to help you make your products better and for less money whenever possible. That takes ingenuity and engineering experience in not just one or two industries but in *all* industries. The Fafnir Bearing Company, New Britain, Conn.

MOST COMPLETE LINE IN AMERICA

**FAFNIR**
BALL BEARINGS

# *Did you know that SHIMS can be MADE ADJUSTABLE?*

**...to cut machining costs**
**...to save assembly time**

Laminated shims, stamped from sheets of *LAMINUM**, are **adjustable.** Laminations of .002 or .003 inch brass or steel simply p-e-e-l off with a penknife, right at the job!

## *HERE ARE THE ADVANTAGES:*

1. No more filing or precision machining or grinding. Laminated shims can take care of increased component tolerances.
2. No fumbling or counting loose shims. The pack is *bonded* together although it peels easily.
3. No dirt, oil, grease between shim layers. Shim is always uniform in gauge, clean and smooth as glass.
4. Actually *less* compressible than stacked or one-piece shims.
5. No standby lathe or operator—no new skill required.
6. Can be fitted with babbitted lugs to prevent oil or pressure loss.

**FOR PRECISION ADJUSTMENT OF SPLIT BEARINGS, GEAR MESH, END-PLAY—ACCURATE SPACING OF MACHINERY COMPONENTS.**

*Send today* for our new data file with specifications, design factors and applications. Sample of *LAMINUM* included.

**STAMPING • GRINDING METALWORKING SERVICES**

Press capacity to 100 tons, 24 inches square, shallow draw. Special equipment and variety of dies can eliminate die-making for short runs. Wide stock of materials. Let us quote on your difficult jobs.

*LAMINUM (Reg. U. S. Pat. Off.) shims are solidly bonded units made up of .002 or .003 inch brass or steel laminations with a microscopic layer of metallic binder. Cut to your exact specifications.

**LAMINUM**
THE SOLID SHIM THAT *peels* FOR ADJUSTMENT

**LAMINATED SHIM COMPANY, Inc.**
140 Union Street Glenbrook, Conn.

SHIMS SHIM STOCK STAMPINGS AN-COR-LOX NUTS

# PAGE WIRE

LOW CARBON
HIGH CARBON
STAINLESS
SPECIAL ALLOY
ARMCO IRON

**You draw the Shape —Page can draw the Wire**

—the way you want it for your production—whether it's ALL of your product, or only a part.

Cross-sectional areas up to .250" square; widths to ⅜"; width-to-thickness ratio not exceeding 6 to 1.

***for Wire or Information about Wire—***

*Get in touch with Page!*

**ACCO**

Monessen, Pa., Atlanta, Chicago, Denver, Detroit, Los Angeles, New York, Pittsburgh, Philadelphia, Portland, San Francisco, Bridgeport, Conn.

PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE

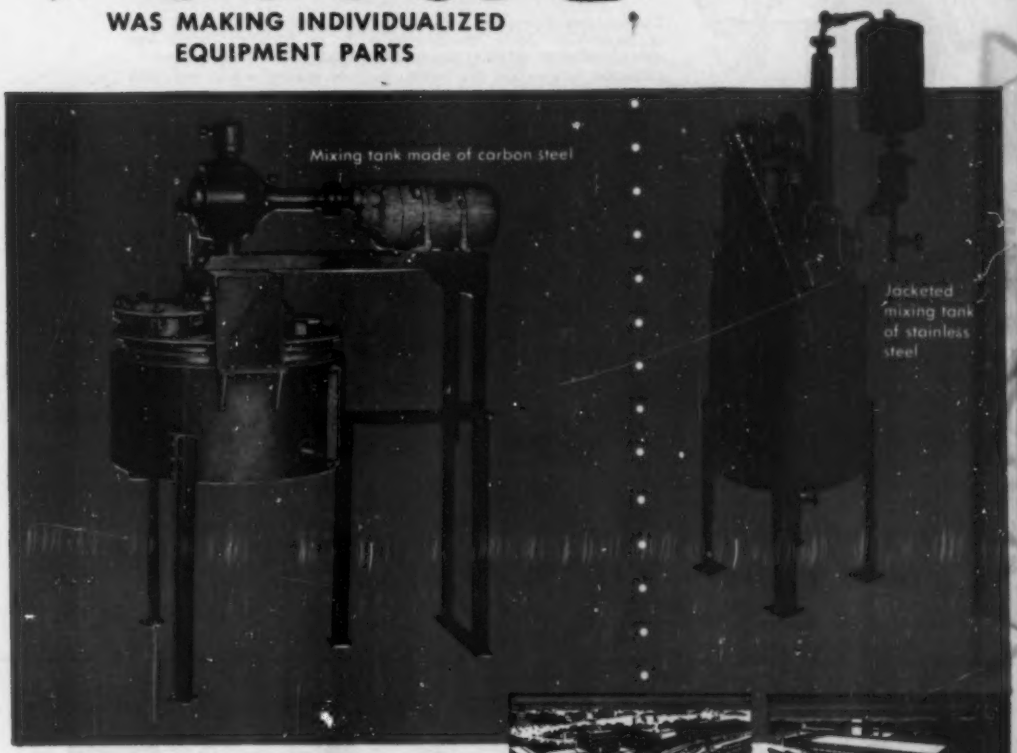
WHEN EDISON INSTALLED
THE FIRST COMMERCIAL
GENERATING PLANT

# Koven

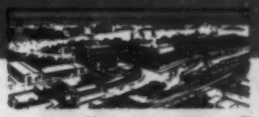
WAS MAKING INDIVIDUALIZED
EQUIPMENT PARTS

Today, power generation is one of the indispensable sources of energy for industrial activity—sixty-odd years ago, it was a new experiment. KOVEN, too, began its service to industry in the early eighties, and through the years, leading manufacturers have depended increasingly on KOVEN for individualized equipment parts that speed production and lower cost. Expert engineering and designing skill, plus the vast resources of two huge plants, enable us to build the part or parts of equipment you require at a possibly lower figure than it would cost you to manufacture them. Call or write KOVEN today for a consultation with one of our trained representatives—no obligation.

Our two modern plants are equipped with machine, welding, plate and sheet metal, galvanizing and painting shops. X-ray inspection insures quality control.




L. O. KOVEN & BRO., Inc.
154 Ogden Ave., Jersey City 7, N. J.



Plants: Jersey City, N. J. Dover N. J.

**KOVEN FOR INDIVIDUALIZED EQUIPMENT PARTS SINCE 1881**

# Why Bundyweld is

When there's even a hint that your product, design or production problem calls for a tubing, think of Bundyweld Tubing!

However you use it—in a design, structural or functional application—Bundyweld delivers all-round rugged, long-lived, *dependable* performance through thick and thin, heat and cold, stress and strain.

In short, no other tubing can match all Bundyweld's advantages, for no other tubing is made like Bundyweld . . . as witness below.

***BUNDYWELD'S GRAND WITH DESIGNERS OF BRAKES— IT FIGHTS OFF FATIGUE FROM VIBRATION AND SHAKES.***

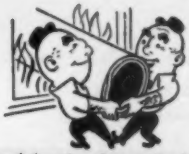
Every automobile produced today contains an average of 20 parts of Bundyweld. More, Bundyweld is in the hydraulic brake line systems of 95% of today's cars! If strength and high resistance to vibration fatigue are *the* factors in your tubing needs, you need Bundyweld.

***IT'S DUCTILE, IT'S LIGHT, AND IT'S EASY TO BEND; YOUR SAVINGS IN COSTS ARE A FINE DIVIDEND.***

Easy-to-handle Bundyweld fabricates like a charm. It bends more readily and takes more bending. It gives you a competitive edge from lowered fabrication costs, whether you're concerned with beer coils, tubular frames, radiant heating systems, or just a "gimmick" made from a tubing.

First, a single strip of basic metal, coated with a bonding metal, is . . .

rolled twice around into a tube of uniform thickness, then . . .



passed through a furnace. Bonding metal fuses with basic metal, presto—

Bundyweld . . . double-walled and brazed through 360° of wall contact.

# the dependable tubing

***NO LEAKS UNDER PRESSURE—FROM WITHIN OR WITHOUT; OF BUNDYWELD QUALITY THERE IS NO DOUBT.***

Special note to users of beer coils, gas and refrigerant lines, compressor and connector lines and the like! Halogen vapor leak detector tests, accurate for 1/100 ounce leak *per year*, score Bundyweld 'way at the top for leakproof performance. It's rolled up *tight* and brazed through 360° of wall contact.

***WE CHECK EVERY INCH WITH A TRUE EAGLE EYE— YOU GET THE DIMENSIONS THAT YOU SPECIFY.***

Use of close-tolerance, cold-rolled strip assures amazingly consistent wall thickness, I.D., and O.D. in Bundyweld. Coating of finished tube, inside and out, is clean and bright. You get extra savings through a minimum of costly inspections.

***WE—LITERALLY—LATERALLY ROLL IT UP DOUBLE, GAIN GREAT EXTRA STRENGTH THAT FREES YOU FROM TROUBLE.***

Yes, it's double-walled from a single strip . . . extra-rugged and strong. Your key to a smarter, sturdier, better product —or to faster production, at less cost—may well lie in an application of Bundyweld somewhere along the line.

**So . . .**
If *your* tubing job needs a neat panacea,
Check Bundyweld fast . . . 'tis a brilliant idea.
You can get it in nickel, or steel, or Monel.
Add a plus to your product that really will sell.

**FREE!** We've a new 20-page booklet giving all the facts and data on Bundyweld Tubing, plus a list of tested Bundyweld applications that will give you a real fill-in on what our tubing can do. For your copy, or for queries on a possible use of Bundyweld Tubing, just call or write . . .
***Bundy Tubing Company, Detroit 14, Michigan.***

# Bundyweld® Tubing

**DOUBLE-WALLED FROM A SINGLE STRIP**

Bundy Tubing Distributors and Representatives: Cambridge 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • Chattanooga 2, Tenn.: Patton-Dodkins Co., 823-824 Chattanooga Bank Bldg. • Chicago 32, Ill.: Lapham-Hickey Co., 3333 W. 47th Place • Elizabeth, New Jersey: A. B. Murray Co., Inc., Post Office Box 476 • Philadelphia 3, Penn.: Eaton & Co., 404 Architects Bldg. • San Francisco 10, Calif.: Pacific Metals Co., Ltd., 3100 19th St. • Seattle 4, Wash.: Eagle Metals Co., 3628 E. Marginal Way Toronto 5, Ontario, Canada: Alloy Metal Sales, Ltd., 881 Bay St. • Bundyweld Nickel and Monel Tubing is sold by distributors of Nickel and Nickel alloys in principal cities.

***Mites in Size; Mighty in Power***

# NEW SCHRADER BANTAM-SIZE AIR CLAMPS

BASE MOUNTED TYPE SHOWN
*(Leg Mounted Type also Available)*

**WEIGH LITTLE**
**COST LITTLE**

Do you know what a tremendous saving in time and muscular effort can be made by using Air Clamps for holding work in position to be processed? Air Clamps have obsoleted manual or mechanical devices for holding work. And here are the Air Clamps that make *every* application practical and economical.

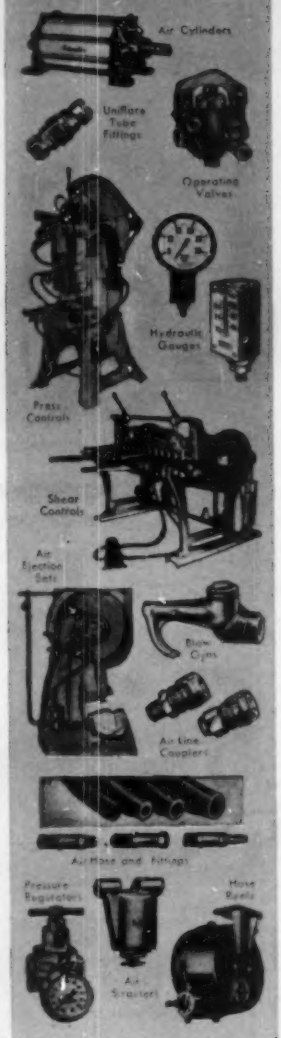
The new Schrader bantam-size Air Clamps save space—they pack all the power possible into the least dimensions; Piston and body are ruggedly constructed for long, hard use. Body is of precision-machined cast brass—easily maintained. And Schrader Air Clamps are adaptable to practically any type of application. There are two types of mountings, base or leg; six models in each type—strokes of 1 to 2 inches; cylinder diameters—1", 2¼" and 3".

There's a Schrader Air Clamp for every application and they weigh so little and cost so little you need not hesitate to design them into production machines with confidence.

Write for a complete catalog data sheet today.

**NEW THREE WAY VALVE** This valve is especially designed for use with above cylinders. The valve body houses a precision lapped stainless steel disc which slides on a bronze ring providing positive sealing action—featuring ease of maintenance. Can be operated manually or mechanically.

**A few of the thousands of Schrader Air Control Products**




MAIL THIS COUPON TODAY

**A. SCHRADER'S SON, 496 Vanderbilt Ave., Brooklyn 17, N. Y.**
*Division of Scovill Manufacturing Company, Incorporated*

Please send me information and free literature about the products I have checked in the squares at the right.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

Schrader
PRODUCTS CONTROL THE AIR

Check Here

- Air Cylinders ☐
- Operating Valves ☐
- Press & Shear Controls ☐
- Air Ejection Sets ☐
- Blow Guns ☐
- Air Line Couplers ☐
- Air Hose & Fittings ☐
- Hose Reels ☐
- Hydraulic Gauges ☐
- Pressure Regulators & Others ☐
- Air Strainers ☐
- Uniflare Tube Fittings ☐

# What is the standard for Standard

Frankly, our standards for quality and precision are plagiarized! For nearly two decades as dependable suppliers to the makers of outstanding products of all kinds, The Standard Products Company has had only one aim — to provide exactly what was specified for fineness, durability, fit . . . and economical cost.

So the standard for our products is set for us in each instance. Our ability to produce just what you want and deliver just when you want it is assured by close engineering cooperation with you, plus practical experience and skilled production.

There is a place in your improved product for PRODUCTS BY STANDARD: thermo-plastic parts or sections . . . rubber parts and insulation . . . latching devices and stamped metal parts.

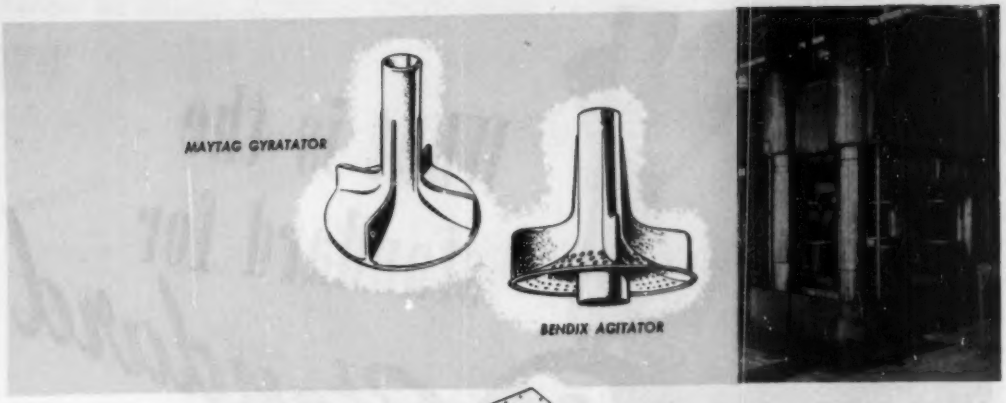
THE MARK OF A SUPERIOR PRODUCT

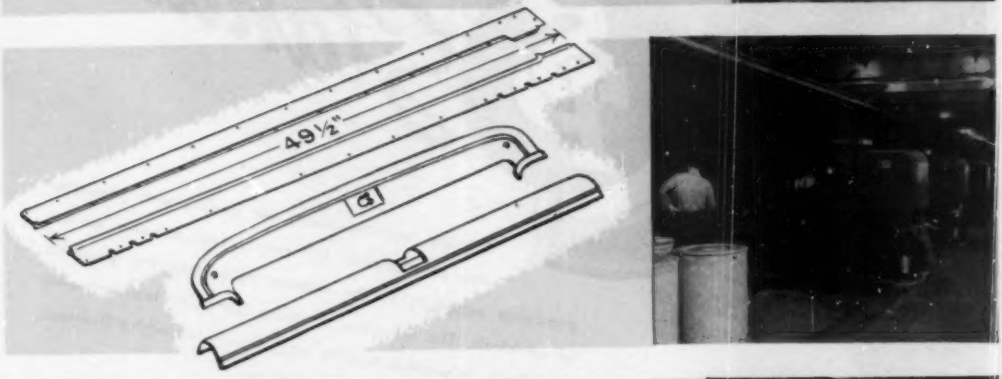
## The Standard Products Co.

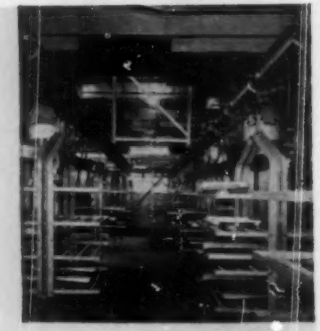
EXECUTIVE OFFICES — 2130 W. 110th ST. CLEVELAND 2, OHIO

SALES OFFICES — 316 FISHER BLDG., DETROIT 2, MICH.

Plants Located in Port Clinton, Ohio; Cleveland, Ohio; St. Clair, Mich.; Gaylord, Mich.; Long Beach, Calif.; Windsor, Ontario





# cut your molding costs with new applications... mass methods... at

NATIONAL PLASTICS EXPOSITION SPE 1950
NAVY PIER CHICAGO MARCH 28-31
BOOTH 136

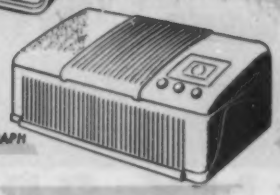
# General

GENERAL PLASTICS DIVISION

## MULTI-CAVITY COMPRESSION MOLDING

At last—"large part" users can have a combination of big equipment and ingenuity to reduce expenses and enable new applications in plastics. General American equipment includes compression presses up to 2,000 tons—and die-makers and set-up men who know how to use this equipment to its best advantage. That's the reason why so many television, radio and top-ranking appliance manufacturers now come to General American.

TELE-TONE TELEVISION SET



PHILCO RADIO-PHONOGRAPH

## BIG INJECTION PIECES POSSIBLE

The economy of molding high-impact polystyrene in large pieces has proved itself at General American. The Frigidaire breaker strip shown here is 49½ inches long. The other parts illustrated have given important savings to such famous manufacturers as Servel, International Harvester, Norge, Crosley, Westinghouse, Frigidaire, Kelvinator, Admiral and Coolerator. Close tolerances in these pieces is essential—and a specialty at General American. Injection presses from 2 to 48 oz. are available.

## MECHANIZED PAINTING AND ASSEMBLY

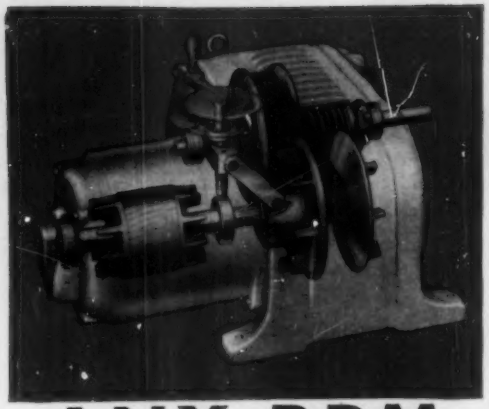
To back up your production line, General American offers you high speed, completely mechanized Logoquant treating and painting of polystyrene. General American has reached an exceptionally high mechanical efficiency in painting and assembly.

# American

## General American Transportation Corporation

135 SOUTH LA SALLE STREET, CHICAGO 90, ILLINOIS

NEW YORK 17—10 East 49th Street • DETROIT 2—3049 East Grand Boulevard



# ANY RPM

## THOUSANDS of SPEEDS

### AT THE TOUCH of YOUR HAND

You can diminish or increase the speed of your machines to the exact rpm required for top production by installing the U. S. Varidrive Motor. It's the original all-in-one unit that eliminates cone pulleys, gear-changing contraptions or extraneous speed changers. A convenient control handle is operated for instant change from speed to speed. You'll get more production and synchronize the speed to the operator's ability. The improved U. S. Varidrive embodies the new Autotaut belt tensioner which counterbalances varying loads so that no slippage occurs.

*U. S. VARIDRIVE MOTOR*

**1 TO 10,000 RPM** **¼ TO 50 HP**

When you use a U. S. Varidrive you can count on the full rated horsepower at the power take-off shaft. There are countless applications for the Varidrive. It regulates speed of machinery to compensate for variation in workers' abilities; permits quick change to give the right speed for different types of work in production; it adjusts speeds to compensate for changes in viscosity, temperature, humidity or quantity, etc. Think of the numerous applications in your plant where variable speed will increase production efficiency—then apply Varidrives.

***A tip to the very wise—buy Varidrives***

***U.S. ELECTRICAL MOTORS, Inc.***

**Los Angeles 54, Calif.** **Milford, Conn.**

**MAIL THIS COUPON FOR DESCRIPTIVE BULLETIN.**

PE

Los Angeles 54 or Milford, Conn.
Send Bulletin 1515 featuring U .S. Varidrive Motor.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

***WHEN YOU . . .***

## Disconnect, You Stop the Flow in *Both* Ends

Wherever the flow of air, fluids, or gases must be interruped, Wiggins *INST-O-MATIC* couplings are lowering costs. Uncouple a Wiggins. You've automatically stopped the flow in both ends. Connecting, or disconnecting, is as simple as switching on a light. Wiggins *INST-O-MATIC* couplings can increase efficiency in your plant today, and lower costs.

**EQUIPMENT MANUFACTURERS**

Users' experiences prove conclusively that this design stands up longer under extreme pressure and vibration, and rarely requires replacement. Inquire today.

BASIC SIZES: ¼", ½", ¾"; also intermediate sizes where needed. Unconditionally guaranteed to be leak proof from 0 to maximum recommended pressure.

**Wiggins**

QUICK DISCONNECT
INST-O-MATIC COUPLINGS

For proof of performance, write for name of nearest representative. E. B. WIGGINS OIL TOOL CO., INC., 3424 E. Olympic Blvd., Los Angeles 23, Calif.

For designers, production men, sales executives, merchandise men and buyers in all industries and businesses. See all the latest advances in the world of plastics. See how to use plastics in all forms, old and new — to stimulate the sale of *your* products. Over 100 exhibits, showing materials, machines, finished products. Consult with the experts — they'll be there!

**CHICAGO**
**NAVY PIER**
•
**MARCH 28-31**
**1950**

**Guest Tickets:** This exposition is not open to the public. Guest tickets are available free on request by writing (on your company letterhead) to —

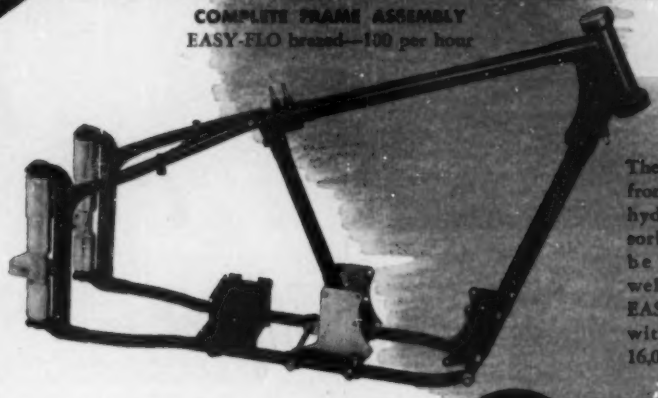
**THE SOCIETY OF THE PLASTICS INDUSTRY, INC.**
295 MADISON AVENUE, NEW YORK 17, N. Y.

# EASY-FLO adds cost-cutting strength to the new Indian lightweight frame

**HANDLEBAR**
EASY-FLO brazed in approximately 40 seconds

Indian Motorcycle Co. is one of many manufacturers who have found—(1) that EASY-FLO brazed construction satisfies all strength requirements—(2) that EASY-FLO brazing is naturally fast and economical—(3) that production can be stepped up to any required volume by using a fast heating method and a set-up that includes preplacing the alloy—(4) that far less finishing is required. Parts pictured are from the 1950 lightweight model. Tubing is AISI 4130 chrome-molybdenum steel. All tubular joints are induction brazed with rings of EASY-FLO wire preplaced.

**COMPLETE FRAME ASSEMBLY**
EASY-FLO brazed—100 per hour



**FORK TUBES**
These tubes form the front fork and act as hydraulic shock absorbers. Joints must be leak-tight as well as strong. The EASY-FLO joint has withstood a load of 16,000 pounds.

**CLUTCH DRIVER**
Studs are EASY-FLO brazed, 30 drivers per hour, 5 studs each. Front and back views show complete EASY-FLO penetration.

## WHAT WILL *EASY-FLO* BRAZING DO FOR YOU?

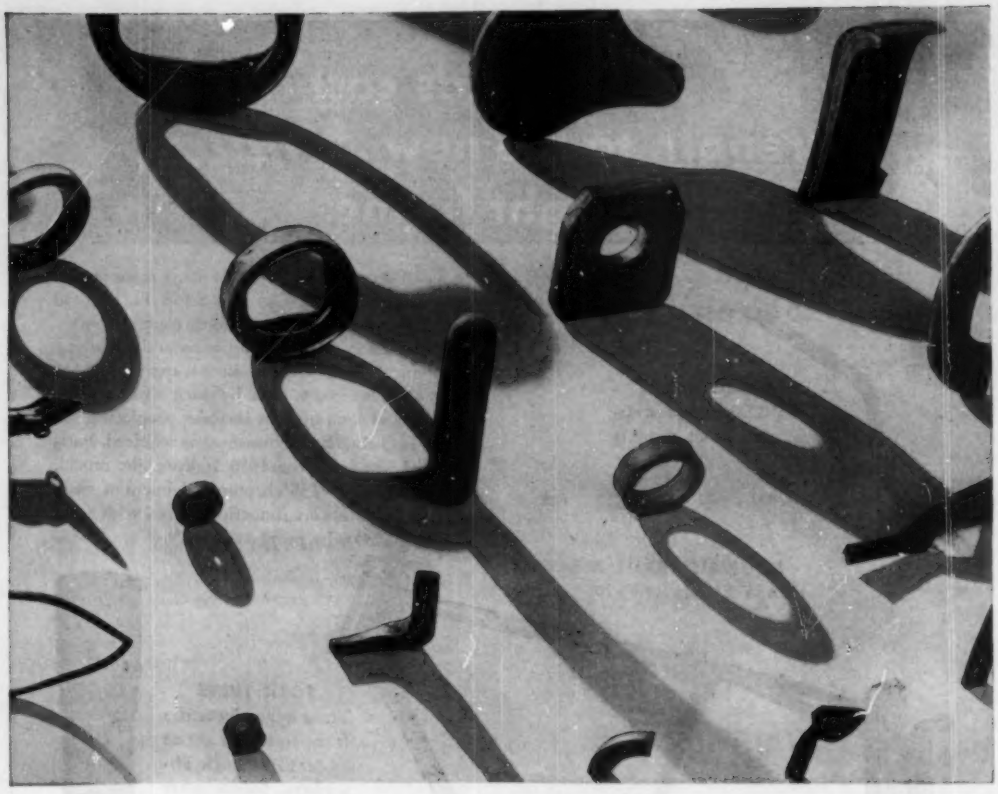
If you join metals—ferrous or non-ferrous—it is fairly certain that EASY-FLO low temperature silver alloy brazing will speed up production and cut costs on part or all of this work. To find out where and how, write or call and ask us to send a service engineer. He'll demonstrate EASY-FLO brazing and discuss its application to your work. There's no obligation to you for this service.

**BULLETINS 12-A, 15 AND 17** will give you EASY-FLO facts in print. Write for copies today.

## HANDY & HARMAN

**82 FULTON STREET NEW YORK 7, N. Y.**

Bridgeport, Conn. • Chicago, Ill. • Los Angeles, Cal. • Providence, R. I. • Toronto, Canada
*Agents in Principal Cities*



## ENGINEERING in cellular rubber that keeps pace with your *imagination*

In some minds Spongex cellular rubber is a vibration pad for huge hydraulic presses, to others it is a powder puff. For other thousands Spongex is of a density and compression range that was especially compounded to do their job best. There seems to be no limit to man's imagination in creating new uses for Spongex.

In serving man's creative mind our laboratory has formulated over 60,000 recipes for cellular rubber. Each applies one or more of the known qualities of Spongex to insulate against shock, vibration, sound, air and temperature.

In every industry there exist problems that Spongex may solve. Whenever your thoughts are on vibration, insulation, cushioning, gasketing, sealing or sound damping, think about Spongex. It can be your biggest help.

Spongex cellular rubber is available in molded shape or die cut form—or in sheets, slabs, strips, cord, tubing, or bonded to metal or fabric.

Write for *Technical Bulletin on Sponge Rubber* today.

*The World's Largest Specialists in Cellular Rubber*

**THE SPONGE RUBBER PRODUCTS COMPANY**
302 DERBY PLACE — SHELTON, CONNECTICUT

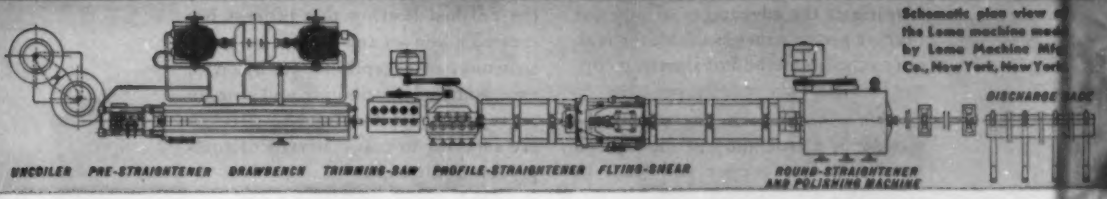
# Amazing Lomatic Doubles and Triples Past Output

# EMPLOYS

# OILGEAR

## AT CRUCIAL POINTS

Exit end of drawbench showing the twin Oilgear Fluid Power Pumps.




Schematic plan view of the Loma machine made by Loma Machine Mfg. Co., New York, New York

AN unusual type of rod-processing machine produces finished stock at a rate two to three times faster than on conventional drawbenches or other types of continuous drawbenches.* Drawing, straightening, shearing and polishing of brass rod are done in one operation on these Oilgear-equipped Lomatic machines.

Oilgear variable delivery pumps, cylinders and valves operate feed roll clamp to start rod through the pre-straightener. The Oilgear equipment provides synchronized operation in tandem and high-speed alternate drop-back in the draw carriage cycle. These functions are crucial to the successful operation of the Lomatic. The wonderfully smooth and steady drawing speed gained from Oilgear equipment means the production of uniformly high quality stock. The operator has full manual control of his machine for set-up and test purposes. He has remote pushbutton control of each carriage . . . and full automatic continuous operation. These superiorities result from the Oilgear simplified fluid power and control system.

Here is another outstanding achievement in machine design where Oilgear Fluid Power plays an important role in enabling the designer and builder to gain the requisite flexibility of application and control of power, simplicity of construction, engineering and installation, sturdiness, and built-in protection against overload.

You can do things with *this* power you *CAN'T* do with any other power . . . and you can do them *BETTER* with Oilgear Fluid Power equipment. What is your problem? Write THE OILGEAR COMPANY, 1571 W. Pierce Street, Milwaukee 4, Wisconsin.

*See article "Brass Rods" published in THE IRON AGE, April 14, 1949.

See Sweet's 1950 File for Product Designers, Section 4C/6.

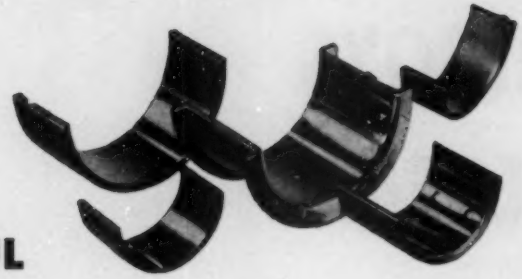
Oilgear

**PIONEERS IN FLUID POWER**

*Pumps, Motors, Transmissions, Cylinders, and Valves*

# ✓LONGER BEARING LIFE

# ✓HIGHER PERFORMANCE STANDARDS



## FEDERAL-MOGUL *Sintered* COPPER ALLOYS

Investigate the advantages of superior bearing performance available through our exclusive method of sintering copper lead alloys.

In this process each tiny particle of powder is a true alloy of the desired proportions of copper and lead. In the finished bearing this process has created a known and controlled grain structure, of exceptional purity, with excellent lead distribution and with no segregation. Its ductility and strength are superior to cast materials of comparable analyses.

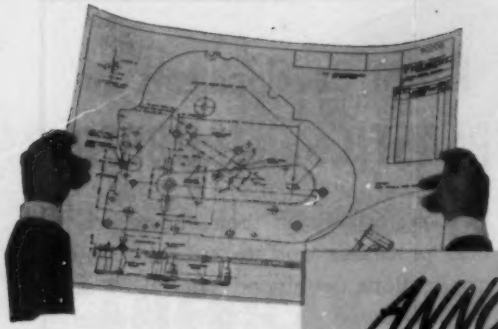
A request on your letterhead will bring a copy of our illustrated technical bulletin describing the development of this improved alloy made possible through powder metallurgy. We believe you will find it a worthwhile addition to your reference file.

**FEDERAL-MOGUL CORPORATION, 11043 Shoemaker, DETROIT 13, MICH.**

FEDERAL Mogul Silent SLEEVE BEARINGS

*Over 50 Years of Continuous Bearing Experience*

Kodak
TRADE-MARK

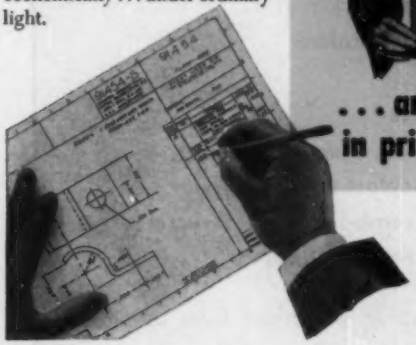


# ANNOUNCING
## Kodagraph Autopositive Film

## . . . and 4 new advantages in print production for you

**1. It gives you faster printing intermediates.** Now you can speed up quantity print production . . . save time and money . . . with new Kodagraph Autopositive Film! What's more, you, or your local blueprinter, can expose this amazing reproduction material in high-intensity blueprint or direct-process machines . . . or in a vacuum frame; develop it in standard photographic solutions. You get positive intermediates directly . . . and the job can be done quickly, economically . . . under ordinary light.

**2. It holds detail—amazingly.** Kodagraph Autopositive Film combines a high-contrast photographic emulsion and famous Kodak safety film base. It catches the finest line—keeps close lines from "filling in." Think what an aid this new intermediate material will be in producing print-making "masters" from difficult originals . . . how it can save you many thousands of dollars in redrafting costs—while assuring final prints of highest quality!



**3. It simplifies revision, reference.** Both sides of Kodagraph Autopositive Film are matte-surfaced . . . can be written on with pencil or pen. And since the base is highly translucent, details can be read from either side without use of an illuminator.

**4. It even reproduces illustrations and text on opaque stock**—giving you sharp, fast-printing "masters" which will produce sparkling direct-process prints. An economical short cut you'll appreciate in preparing data sheets, instruction manuals, and parts lists.

**Mail coupon today** for this free illustrated booklet giving all the facts on Kodagraph Autopositive Film—*the latest addition to the famous Kodagraph line of reproduction materials.*

**EASTMAN KODAK COMPANY**
**INDUSTRIAL PHOTOGRAPHIC DIVISION**
**ROCHESTER 4, N. Y.**

18

Gentlemen: Please send a copy of your folder on Kodagraph Autopositive Film.

Name _____ Position _____
(please print)

Company _____ Street _____

City _____ State _____

# Purebon

***solves many problems***

**caused by sliding or rotating parts which are difficult or impossible to lubricate**

A constantly increasing stream of problems are facing engineers and designers today involving sliding or rotating parts where lubrication is difficult or impossible. For such applications, Purebon, the mechanical carbon, is often the ideal answer. Typical applications are seal rings, bearings, pistons, piston rings, pump vanes, valve seats, meter discs, and a host of similar items. Purebon comes in a wide variety of grades. It is strong, tough, readily machineable and in many cases can be molded directly to size.

Bulletin No. 482 tells the complete story of Purebon. Write for your copy today.

**PURE CARBON CO., INC.**

448 HALL AVE. ST. MARYS, PA.

## Recent Developments in PLASTICS and RUBBER

New materials and their characteristics, processes and techniques, and applications developed since the war are reviewed in a 32-page report which appeared in the April 1947 issue of *Product Engineering*.

This valuable reference for design engineers summarizes working data on

**Polytetrafluoroethylene**
**Modified Styrenes**
**Polyethylene**
**Vinyl Plastics**
**Plastics-Synthetic Rubber Combinations**
**Synthetic Rubber**
**Nylon**
**Silicones**
**Cellulosic Plastics**
**Thermoplastic Laminates**
**Honeycomb-Sandwich Structures**
**Protective Coatings**

*Reprints in pamphlet form available at 25¢ each from*

***Readers' Service Department***

**PRODUCT ENGINEERING**

**330 West 42nd Street, New York 18, N. Y.**

# AMERICAN WELDING

## "Controlled Technique"

**can be applied to**

## Your Products

Fabrication of your products by American Welding will enable you to make better products and with appreciable manufacturing economies!

Our facilities include all types of resistance and fusion welding applicable to both ferrous and non-ferrous metals and alloys in rings, bands and weldments. Heat-treating and machining facilities are available.

Over 32 years of welding and fabricating experience is yours for the asking. Skilled designers, engineers and metallurgists will gladly apply this experience to your requirements without obligation. Send prints and specifications for prompt quotation.

***SEND FOR NEW 20-PAGE CATALOG!***

**THE AMERICAN WELDING & MANUFACTURING CO.**

**140 DIETZ ROAD • WARREN, OHIO**

# Here's how CMH FLEXIBLE

## solves product designers' basic motion

### MISALIGNMENT

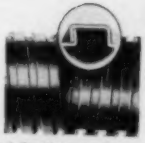
● In the gas connections of the coke oven illustrated CMH corrugated metal hose solves the misalignment problem and compensates for expansion and contraction, as well. The use of CMH Flexible Metal Hose for making connections between misaligned sections of piping frequently saves time and money . . . it eliminates the need for complicated piping and an excessive number of fittings . . . it also simplifies and speeds up assembly and disassembly of the piping.

### VIBRATION

● Vibration in the room air conditioner refrigerating unit shown above was isolated by means of CMH Vibra-Sorbers (short lengths of flexible metal hose). In all products which incorporate vibrating components such as compressors, turbines, engines, etc., CMH flexible metal hose used as the connecting link to fixed piping effectively isolates the damaging effects of vibration and minimizes objectionable noise.

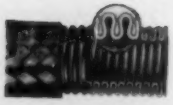
**CMH**
**ONE DEPENDABLE SOURCE for every flexible metal hose requirement**

FLEXON identifies CMH products that have served industry for over 40 years.



Metal Conduits in a variety of types and materials.

Convoluted Metal Hose in a variety of types—steel bronze and alloys.



Corrugated Metal Hose in steel, bronze stainless steel and other alloys.

Expansion Joints for all pressures—copper, stainless steel and other alloys.

Bellows for all requirements —brass, stainless steel and other alloys.

Standard Assemblies of metal hose components for specialized applications.

Leaders in the Science of Flexibility

# METAL HOSE

## problems of conducting liquids, gases and solids

### EXPANSION

● The gas connections in this heat treating furnace are subjected to expansion and contraction as the furnace is brought up to operating temperature. Short lengths of CMH flexible metal hose solve this problem and eliminate the misalignment problem, too. Use CMH flexible metal hose or expansion joints in all products that include piping which is subject to expansion and contraction.

### FLEXATION

● The steam connections for this rubber molding platen press are typical of how CMH flexible metal hose is used for moving connections on everything from rugged tire vulcanizers to delicate weigh tanks. When connections between moving sections are made with CMH flexible metal hose, the lines are able to offer maximum resistance to external damage and at the same time withstand high temperatures, high pressures and frequent, repeated motion for long periods.

IN CMH's complete line of flexible metal hose products there is the exact type to meet your needs. Pressures from vacuum to 12,000 psi (burst) and temperatures from far below 0° to 1600° F. can be accommodated by the various types. CMH flexible metal hose is manufactured in a wide variety of metals including types which are corrosion resistant, fire resistant and able to hold extremely searching liquids and gases.

Whatever your connection problem, if there is misalignment, vibration, expansion or flexation, CMH offers the economical, dependable, safe solution. If you do not already have literature describing the CMH line of flexible metal hose products, write for it today mentioning the types of connection problems you have.

**CHICAGO METAL HOSE CORPORATION**

1351 S. Third Avenue — Maywood, Illinois

In Canada: Canadian Metal Hose Co., Ltd., Brampton, Ontario

Plants at Maywood, Elgin and Rock Falls, Illinois

# 43 GEARMOTORS drive series of 3 Conveyors..

## ...at Benwood Works of Wheeling Steel Corp.

This interesting installation is typical of the versatility and efficiency of Philadelphia GearMotoR applications . . . It consists of 43 2 h.p. units operating from "Reliance" 30 V*S Drives to provide speeds that vary from 50 to 500 r.p.m. The Philadelphia GearMotoR is used by hundreds of companies throughout industry because: It is a self-contained, extremely compact unit that conforms to recommended standards of A.G.M.A. and N.E.M.A.; it is available in single, double and triple reductions (range of speeds run from 780 through 7.5 r.p.m.;) motor rating from 1 h.p. through 60 h.p. . . . A-c or D-c Motors are precision-built and fit perfectly with gear unit. Gears are helical type, (long-lived and quiet) and made of quality alloy steel, precision machined (teeth shaved) and induction-hardened. Assembly is very simple: Motor and gear units are each self-contained, yet readily separated; gears in multi-reduction units may be inspected without uncoupling from driven machine. Lubrication is of positive "splash type," with large reservoir. Gear housing is leak-proof, and motor (which is greased independently) has double-shielded ball bearing design.




Send for 42-page illustrated catalog, and please use your Business Letterhead when requesting it.

# Philadelphia Gear Works, INC.

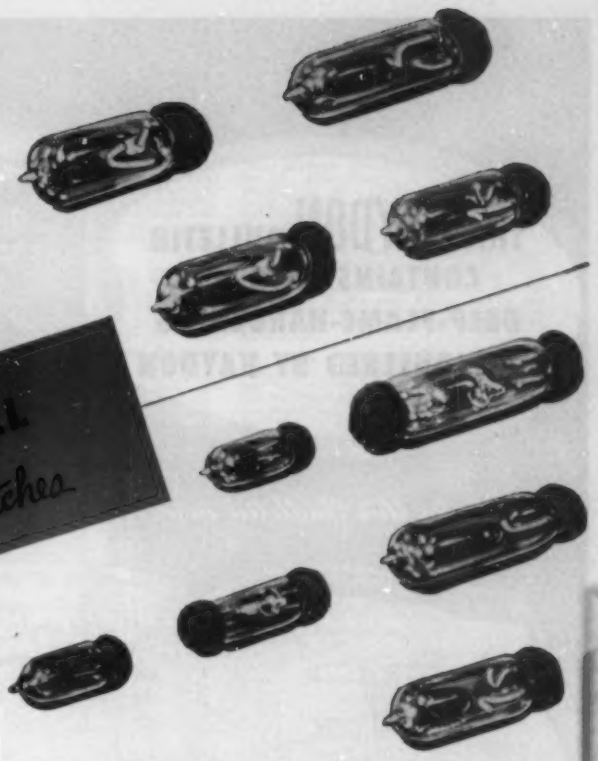
ERIE AVE. AND G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON
IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

*Industrial Gears and Speed Reducers*
*LimiTorque Valve Controls*

A COMPLETE LINE OF LOW-COST, LONG-LIVED, MAINTENANCE-FREE

HONEYWELL *Mercury Switches*

FOR GREATER LATITUDE IN PRODUCT DESIGN



Simple, dependable on-off switching is a must with many products . . . and generally, the shortest distance between the problem and the solution is a Honeywell Mercury Switch.

Honeywell Mercury Switches are tiny and compact . . . are adaptable to unusual mountings. They operate at low angles . . . have no moving parts . . . are sealed against dust, gas and corrosion. Fouled contact points cannot occur.

The complete line is at your command . . . offering greater latitude in product design, with improved performance and trouble-free operation. Write for a copy of new Catalog 1343 for down-to-earth information . . . or call in your local Honeywell engineer for a detailed discussion of a particular application.

COMMERCIAL · RESIDENTIAL · INDUSTRIAL
WORLD'S LARGEST ORGANIZATION FOR ADVANCED INSTRUMENTATION AND CONTROL

MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
4459 Wayne Avenue, Philadelphia 44, Pa.
*Offices in 73 principal cities of the United States, Canada and throughout the world*

FOR
- POSITIVE ACTION
- LOW ANGULARITY
- LONGER LIFE
- WIDE SELECTION

SPECIFY HONEYWELL *Mercury Switches*

Honeywell *Mercury Switches* BROWN
FOR POSITIVE ACTION

## *The* KAYDON *technique of deep-flame-hardening for bearings of unusual shapes, sizes and thin sections*

Designers and users of special machinery will appreciate this information on KAYDON-pioneered deep-flame-hardening which has helped remove bearing-limitations that heretofore proved to be serious handicaps.

This new KAYDON technique in deep-flame-hardening hardens only the raceways of the bearings. This permits the races themselves to be accurately drilled, tapped and gear-cut . . . eliminates many of the surrounding parts which normally would be necessary . . . results in important weight-reduction . . . makes possible the creation of unusual designs that accommodate minimum sizes of bearings in the space available . . . permits unusual shapes, very large diameters, and extremely thin sections, all of which greatly facilitate mounting.

Write for this Bulletin on KAYDON Deep-Flame-Hardening . . . and when you need the unique services offered, contact KAYDON of Muskegon.

KAYDON Types of Standard or Special Bearings: Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust

**THE KAYDON ENGINEERING CORP., MUSKEGON, MICH.**

• ALL TYPES OF BALL AND ROLLER BEARINGS 4" BORE TO 120" OUTSIDE DIAMETER •

# NEW CATALOGS AND BULLETINS

## A Reader Service To Help Keep Your Library Up-to-Date

**(1) FHP MOTORS**—National Pneumatic Co., Holtzer-Cabot Div., 125 Amory St., Boston 19, Mass. Bulletin, 4 pp. Describes type R-37 synchronous and induction fhp motors, which are built to customer's specifications only, and have power ratings from 1/30 to 1/200 hp. Pictures, drawings, and text give full specifications.

**(2) TORQUE CALCULATORS** — Stow Mfg. Co., Binghamton, N. Y. This slide rule type calculator is for use with flexible shafting and will give all the information usually needed to specify flexible shafting.

**(3) TRANSPARENT DRAWING INSTRUMENTS**—C-Thru Ruler Co., Hartford, Conn. Catalog, 14 pp. Illustrates a complete line of transparent ruling and drawing devices. The company also makes special devices to customer specifications. Prices are also given.

**(4) OIL HYDRAULIC CYLINDER** — Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich. Bulletin 49-55, 28 pp. Photos, drawing, cut-away views, and complete tabulated information describe 10 basic types of oil hydraulic cylinders. Cylinders are available in both single and double end types, and in a variety of mountings.

**(5) MULTIPLE DISK CLUTCHES**—The Carlyle Johnson Machine Co., Manchester, Conn. Data book No. 50, 12 pp. Exploded views and drawings explain design principles of "Maxitorq" floating disk clutches, which are available in several types for machine tool and other machinery applications.

**(6) HIGH-TEMPERATURE STEELS** — United States Steel Subsidiaries, 2150 Carnegie Bldg., Pittsburgh 30, Pa. Booklet, 35 pp. Called, "Steels for Elevated Temperature Service", this booklet gives both tabular and graphic data on the specific mechanical properties of 31 different steels. Also lists further technical literature available on same subject.

**(7) BRONZE BARS** — American Brake Shoe Co., National Bearing Div., 4930 Manchester Ave., St. Louis 10, Mo. Bulletin, 6 pp. Lists sizes and weights of "tiger" bronze cored and solid bars, which are made in all popular sizes. Material has wear and shock resistance and good anti-friction qualities.

**(8) HYDRAULIC TABLES** — Baldwin Locomotive Wks., Philadelphia 42, Pa. Bulletin 300, 22 pp. Intended for use by designers and users of hydraulic equipment, this booklet is filled with formulae and tabulated information on flow rates, friction losses, bolt strength, properties of sections, moments of inertia, and other comparable data.

**(9) ALUMINUM PRODUCTS** — Revere Copper and Brass, Inc., 230 Park Ave., New York 17, N. Y. Bulletin, 18 pp. Describes extruded products, drawn tube and pipe, and coiled sheet made of aluminum. Also has a chart showing properties of wrought aluminum alloys.

**(10) PRE-PLATED METALS** — American Nickeloid Co., Peru, Ill. Folder, 8 pp. Gives pertinent engineering data on brass-base, copper-base, zinc base, aluminum base, and steel base pre-plated metals. Also lists specialty items.

**(11) HYDRAULIC EQUIPMENT** — Hannifin Corp., 1101 S. Kilbourn Ave., Chicago 24, Ill. Bulletin 150, 20 pp. Describes the "Hy-power" pressure generator, which is an automatic hydraulic power source for squeeze riveting, punching, pressing, assembly, shearing, and other such applications. Also describes riveters and other standard components used with the power source.

**(12) PLASTIC TUBING**—U. S. Stoneware Co., Box 350, Akron 9, Ohio. Bulletin T-77, 24 pp. Describes "Tygon", which is a modified vinyl thermoplastic which has been into a pliant, tough material. The physical, chemical, and electrical properties of various formulations are given. Material comes in sheets, tubes, extruded shapes, and solid cords.

**(13) HYDRAULIC PUMPS, MOTORS, TRANSMISSIONS** — Berry Motors, Inc., Corinth, Miss. Bulletin, 20 pp. Pictures, drawings and complete tabulated information describes high pressure pumps and motors for service up to 5,000 psi, oil pressure. Also describes hydraulic transmissions.

**(14) SPEED REDUCER**—The Cleveland Worm and Gear Co., 3251 E. 80th St., Cleveland 4, Ohio. Bulletin 125, 8 pp. Announces two new types of vertical speed reducers. Sizes, speeds, and other data given for both type NU and ND units.

**(15) SAFETY SWITCH**—The Trumbull Electric Mfg. Co., Plainville, Conn. Folder TEC-10, 6 pp. Describes the HC1 safety switch, which has high interrupting capacity, high momentary circuit capacity, and ability to handle short-circuits without damages.

**(16) PLASTIC EXTRUSION**—Tennessee Eastmans Corp., Kingsport, Tenn. Bulletin, 28 pp. Titled "Tenite Extrusion", this booklet presents data on equipment and materials handling for continuous extrusion of "Tenite I", a cellulose acetate plastic, and "Tenite II", a cellulose acetate butynate plastic.

**(17) MOTOR CONTROLS** — Allen-Bradley Co., Milwaukee 4, Wis. Catalog, 4th edition, 76 pp. Gives sizes, prices, and other data on complete line of starting switches, relays, drum switches, push buttons, and other control devices.

**(18) AIR CONTROL VALVES**—Mechanical Air Controls, Inc., 3049 E. Grand Blvd., Detroit 2, Mich. Catalog 49, 20 pp. Describes a complete line of valves for the control of single and double acting air cylinders. Six types of valves are shown, with photos, drawings, and all pertinent data given.

**(19) RIGHT-ANGLE GEAR UNITS** — Airborne Accessories Corp., 25 Montgomery St., Hillside 5, N. J. Bulletin, 4 pp. Shows "angigears" in two basic models: the R-300 universal mounting 3-way, and the R-310 universal mounting 3-way. Units are rated at ⅛ hp at 1800 rpm.

**(20) HEATING ELEMENTS**—Trent, Inc., 4581 Wilde St., Philadelphia 27, Pa. Bulletin 50-T, 4 pp. These heating elements are available in standard size racks. Continuous ribbon-type elements are located in high temperature refractory porcelains, and supported on steel frames.

**HOW TO ORDER**—Two post cards are printed here. On each is room for you to request four pieces of literature. If you are requesting four pieces or less, please use only the bottom card. For five to eight pieces use both cards.

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York. 3-50
Not Good after May 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York. 3-50
Not Good after May 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York. 3-50
Not Good after May 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York. 3-50
Not Good after May 1, 1950

PLACE 3¢ STAMP HERE

PRODUCT ENGINEERING

330 West 42nd St.

New York 18, N. Y.

**(21) ELECTRICAL INSULATING MATERIALS** — Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill. Price catalog 14, 124 pp. A complete catalog of pressure sensitive tapes, asbestos products, glass tapes, fibre products, mica products, plastic films, and other electrical insulating materials.

**(22) SMALL DIESEL ENGINES** — Norberg Mfg. Co., Milwaukee 7, Wis. Bulletin 165, 12 pp. Describes small diesel engines in the 10 to 15 hp range. Type HPS1 engines have a bore of 4¼ in., stroke of 5¼ in., and brake hp brake hp rating of 10-15 within 1200 to 1800 rpm.

**(23) CLAMPS, STRAPS, AND COUPLINGS**—Marman Products Co., Inc., 940 W. Florence Ave., Inglewood, Calif. Bulletin, 4 pp. Illustrates and describes a wide line of sheet metal clamps and straps made in a variety of standard shapes and sizes for use with hoses, ducts, sleeves, boots, and other such applications.

**(24) STEEL RINGS**—Dresser Mfg. Div., Dresser Industries, Inc., Bradford, Pa. Folder, 4 pp. Explains manufacturing processes for making stainless and other steel rings from 5 to 120 in. in dia, and up to 3 in. thick. Folder features case history of motor generator frame made of rings.

**(25) PROPORTIONING OIL BURNER**—Hauck Mfg. Co., 124-136 10 St., Brooklyn 15, N. Y. Bulletin 410, 24 pp. This burner is a precision instrument giving more accurate control of furnace temperature and atmosphere. It is available with all the latest developments for "push button" ignition, automatic control of combustion, temperature and flame safeguards. The bulletin explains operating principals and gives many application photos.

**(26) SPEED REDUCERS** — The Falk Corp., Milwaukee 8, Wis. Bulletin 1110, 24 pp. Data on parallel shaft herringbone speed reducers includes a method of selection, hp tables, torque capacity tables, and order guide and dimensions.

**(27) MINIATURE BALL BEARINGS**—New Hampshire Ball Bearings, Inc., Peterborough 1, N. H. Bulletin 50, 12 pp. Describes a line of standard and special ball bearings. Designs include Conrad radial, full face radial, extra light radial, angular contact, and others, in outside diameters from ⅜ to ⅝ in., made in a variety of metals.

**(28) FHP MOTORS**—Price Electric Corp., Frederick, Md. Bulletin, 4 pp. Presents standard model 2 and 4 pole skelton, enclosed, and enclosed-ventilated shaded pole motors from 1/200 to 1/25 hp. Dimensions and other data given.

**(29) O-RING PACKINGS** — Minnesota Rubber and Gasket Co., 3630 Wooddale Ave., Minneapolis 16, Minn. Catalog 9-A, 12 pp. Describes manufacture, uses, and selection of synthetic rubber o-rings for hydraulic packings designed for use on moving parts. Physical characteristics and installation data given.

**(30) METAL TREATING AND FINISHING**—Heatbath Corp., Box 78, Springfield, Mass. Data sheets, 20 pp. Information is given on black finishes, carburizing salts, neutral hardening salts, tempering salts, high speed hardening salts, liquid nitriding salts, and other materials for metal treatment.

**(31) WORM-GEAR SPEED REDUCERS**—De Laval Steam Turbine Co., Trenton 2, N. J. Bulletin G-WB, 24 pp. Contains a complete description of standard IMO horizontal worm gear speed reducers. Shows all available types and gives standard specifications, load ratings, and selection data.

**(32) ROTARY STRAINER**—The Balmar Corp., Woodberry, Baltimore 11, Md. Bulletin, 4 pp. Drawings illustrate operating principles of this self-cleaning rotary strainer for use with steam, air, gas, water, oils, or gasoline. Strainers have pipe connections from 1 to 4 in. Bodies are made in several metals.

**(33) APPLICATION OF STRAIN GAGES**—The Baldwin Locomotive Wks., Philadelphia 42, Pa. Bulletin 279-B, 8 pp. This bulletin tells, in detail, how to apply and use SR-4 strain gages. Cartoons illustrate each step. The bulletin is a basic primer for anyone interested in the subject.

**(34) BRONZE BEARINGS** — Johnson Bronze Co., New Castle, Pa. Catalog 500, 64 pp. Lists and describes a complete line of sleeve bearings, as well as bronze bar stock, bushings, and babbitt metal. Electrical bushings, electric motor bearings, sheet bronze bushings, and machined bronze bars are featured.

**(35) SHAFT SEALS**—Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill. Bulletin, 4 pp. Cut-away views show the operating principles of the bellows-type shaft seal. These seals are for use with centrifugal and rotary pumps, reducers, and other such applications.

**(36) HYDRAULIC PUMPS** — Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich. Catalog 4900, 48 pp. Catalog includes data on oil hydraulic pumps, pressure controls, volume controls, directional controls, control assemblies, hydraulic motors, transmissions, and cylinders.

**(37) CONVEYOR BELTS**—Buffalo Weaving & Belting Co., Buffalo 7, N. Y. Bulletin, 4 pp. Describes 35 belt widths, 7 different belt plies, and 6 different coatings that can be applied to conveyor belts.

**(38) SELF-LOCKING PINS**—The Driv-Lok Pin Co., Sycamore, Ill. Bulletin, 16 pp. The Driv-Lok pin is used in place of taper pins, keys, straight pins, cotter pins, set screws, or rivets. It locks into place when driven into a hole.

**(39) RIVETED ROLLER CHAIN**—Chain Belt Co., Baldwin-Duckworth Div., Springfield 3, Mass. Bulletin 50-6, 8 pp. Describes the Baldwin-Rex "BA" assembly, which is standard riveted roller chain with a special single pin connector link. Construction diagrams, illustrations, list prices, and dimensions are given.

**(40) EXPANSION JOINTS**—Cook Electric Co., Magnilastic Div., 2700 N. Southport Ave., Chicago 14, Ill. Catalog 50, 30 pp. Gives complete information on a variety of bellows-type expansion joint for the transmission of steam, oils, gases, diesel exhaust, acids, and other fluids. Joints will take pressures from vacuum to 1,000 psi at temperatures ranging from −300 to +1600 deg F.

**(41) SWIVEL JOINTS**—Chiksan Co., 330 N. Pomona Ave., Brea, Calif. Catalog 50, 72 pp. Illustrates over 500 types and sizes of ball-bearing swivel joints. Seven basic types are available for temperatures and pressures from 25 to 600 deg F and from vacuum to 15,000 psi. Sizes range from ⅜ to 12 in. Hose and auxiliary equipment are also listed.

**(42) TRANSMISSION BELTING**—B. F. Goodrich Co., Akron, Ohio. Bulletin 2100, 4pp. Recommendations are given for the use of various types of transmission belting. Specifications are given for five standard types of belting and a method of making belts endless is outlined in detail.

**(43) EXHAUST FANS**—Rotron Mfg. Co., Inc., 7-9 Schoonmaker Lane, Woodstock, N. Y. Data sheets, 10 pp. Gives engineering data on model "B" and "C" exhaust fans, which are for continuous duty operation in high ambient temperatures. Typical uses include installation inside enclosures of radio transmitters and instrument cabinets.

**HOW TO ORDER**—Two post cards are printed here. On each is room for you to request four pieces of literature. If you are requesting four pieces or less, please use only the bottom card. For five to eight pieces use both cards.

PLACE 3¢ STAMP HERE

PRODUCT ENGINEERING

330 West 42nd St.

New York 18, N.Y.

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York 3-50

Not Good after May 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York 3-50

Not Good after May 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York 3-50

Not Good after May 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York 3-50

Not Good after May 1, 1950

# on your aluminum contract work, check *first* with THE METAL MEN OF MANITOWOC!

● The voice of experience whispers that good advice in the ear of every conscientious product planner. The Metal Men of Manitowoc, through more than 50 years of processing, fabricating, and finishing aluminum, have built up a bank of ability upon which the industry of America draws daily.

Careful adherence to your specifications is, of course, important. Equally important is the assistance we can give you in *creating* those specifications. Our alloying, engineering, and design departments are always available to you, extending our service beyond making your product, to helping you make it *better* . . . for less money.

ALSO MAKERS OF
MIRRO
The Finest Aluminum Cooking Utensils

**A CONTRACT PLACED WITH US EXPANDS YOUR PLANT TO INCLUDE:**

- Machine Shop and Die-Making Facilities
- Four Large Fabricating Plants
- Spacious Aluminum Rolling Mills
- Wide Range of Stamping Presses
- Heat-Treating Equipment
- Gas and Electric Welding
- Complete Finishing Equipment

**CONTRACT, AUTOMOTIVE, AND AVIATION DIVISIONS**

**ALUMINUM GOODS** *Manufacturing Company*

MANITOWOC WISCONSIN

FIFTH AVENUE BLDG., NEW YORK 10 MERCHANDISE MART, CHICAGO 54

# Do you have METAL SURFACE TREATMENT PROBLEMS ?

## Here are PARKER products to solve them

**All of our work is on the surface! For 34 years we've lived with the problems of metal surface preparation and preservation. Parker research has discovered how to deal with many specialized problems; field experience for three decades and in thousands of plants has taught us many answers, too. Parker Rust Proof Company's vast experience, and the famous Parker Products, are at your command to solve *your* metal surface treatment problems.**

*Want to inhibit rust?*
**...PARCO COMPOUND**

**This is an improvement on the original Parker Product, which has set the standards for controlling rust on iron and steel for more than thirty years. Parco Compound converts the surface of these metals to a nonmetallic phosphate coating that is highly efficient in inhibiting the forces of corrosion. It's an easy, positive treatment, requiring only simple equipment.**

**Parco Compound treats small and large pieces with equal ease. The characteristic color produced by Parco Compound is soft, dark gray. Parcolacs, paint, oils, stain, or wax finishes are used over this versatile rust inhibitor.**

*Want rust preventive finishes?*
**... PARCOLACS**

**This large class of specialized products includes waxes, stains, and oils of varying characteristics to meet the many different requirements of industry. There are Parcolacs for dip application, for centrifuge, for brushing and spray. You can get high**

efficiency in Parcolacs for use as rust preventive finishes; others have been developed to add pleasant, non-marking, high appearance qualities. Your own requirements will dictate which Parcolac is best for your use.

## Want improved paint adhesion and rust resistance?
## . . . BONDERITE

Most widely used of all Parker Products, Bonderite adds quality to many of the most attractive metal products manufactured today. It's under the paint on automobile bodies, fenders, and sheet metal. It is used by most refrigerator manufacturers, and on a great many of the finest domestic appliances. Wherever lasting fine appearance is important on a painted metal product, *there* is a place for Bonderite.

Bonderite converts the surface of metal to a nonmetallic phosphate coating which is an excellent base for paint and, because of its nonmetallic character, an effective rust resistant.

Bonderite is fast and flexible, and can be used in immersion equipment and in automatic conveyor production lines. It is simple to control, producing positive and uniform results at low cost.

## Want faster, smoother draws?
## . . . BONDERITE

The crystalline, nonmetallic Bonderite coating brings these benefits to the drawing bench: It holds lubricant, even under great pressure. It prevents metal to metal contact, reducing galling and scoring. It reduces wear on tools and dies, lengthening the life of these expensive parts. It permits deeper, smoother, faster draws. *Cuts metal polishing costs.*

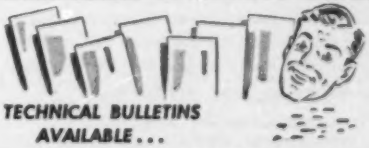
## Want wear resistance for friction parts?
## . . . PARCO LUBRITE

Faster, smoother break-in, greatly reduced danger of scoring and scuffing, and longer subsequent wear are the advantages Parco Lubrite brings to friction parts. The nonmetallic, crystalline coating holds oil under high operating pressures and temperatures. There's no metal-to-metal contact, and the parts "wear-in" quickly and smoothly.

## Want better metal cleaning and rust removal?
## . . . PARCO Formulated CLEANERS

Parco Cleaners are formulated to clean better, go farther, with reduced concentrations of cleaner material required. These products do more than remove rust, soil, or grease; they also *condition* the metal for the next step in finishing.

Parco Cleaners include *Solvent and Emulsion* Types, *Acid* Types, *Alkaline* Types, and *Water Conditioners.*



**TECHNICAL BULLETINS AVAILABLE . . .**

Full information on any of these Parker Products is yours on request. Write for technical bulletins on the Parker Products which can contribute to the solution of your problem and the success of your product.

*Bonderite, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

PARKER

PARKER RUST PROOF COMPANY
2179 East Milwaukee Ave.
Detroit 11, Michigan

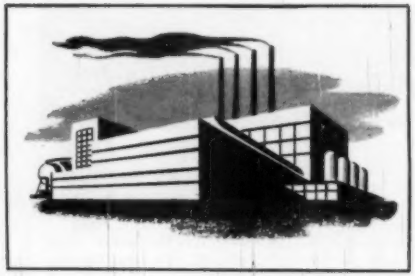
BONDERITE—Corrosion Resistant Paint Base • PARCO COMPOUND—Rust Resistant • PARCO LUBRITE—Wear Resistant for Friction Surfaces

# Bendix-Skinner

ORIGINATOR OF **MICRONIC** FILTRATION

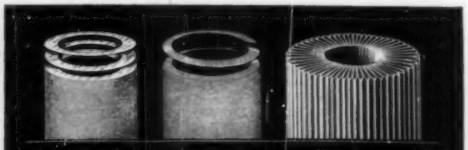
the *Finest*

## Way to Make Liquids Come Clean



Nine times out of ten you'll get a better filtering job with ***Bendix-Skinner*** filters. No magic—just the simple fact that ***Bendix-Skinner*** has developed entirely new and exclusive filtering techniques in twenty years of tackling the tough jobs. We'll welcome an opportunity to prove it. An inquiry costs you nothing and may save you much.

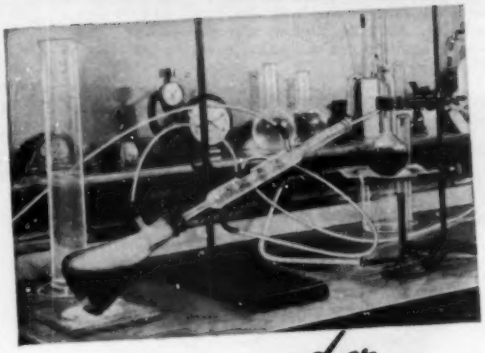
***Over 350 Models*** *providing filtration from ½ micron (.000019") upwards at flow rates from 1 to 5000 g.p.m.*




*SKINNER PURIFIERS DIVISION OF*
1500 TROMBLY AVENUE
DETROIT 11, MICHIGAN
Bendix AVIATION CORPORATION
Export Sales: Bendix International Division, 72 Fifth Ave., N. Y. 11, N. Y.



**Highest Qualifications**



*for*

## MEETING RIGID DEMANDS

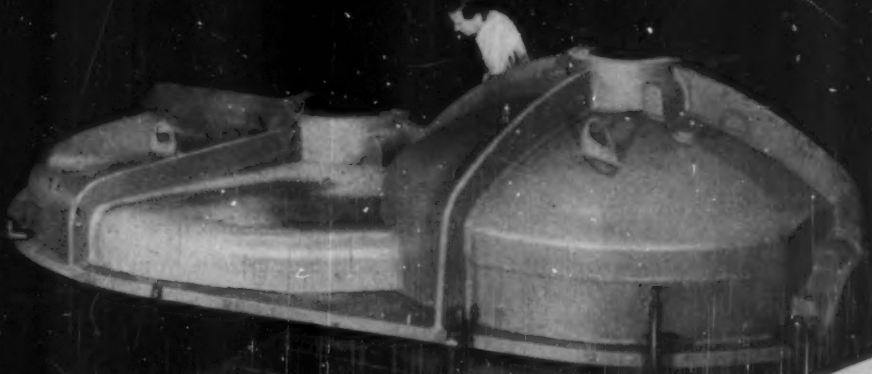
The remarkably wide range of uses to which components made and processed by Western Felt are astonishing. It is serving in scores of industries—from women's hats to 50 ton forge hammers. In the automobile field alone, as an example, this felt has been chosen to best serve in more than thirty purposes.

Western Felt engineers and chemists for decades have worked in close cooperation with users of felt to give them the very highest quality of material, exactness and uniformity. There are still a world of potential uses for Western Felt products, made to almost any shape, size or consistency. They range from wool softness to rock hardness. When cut, it does not fray or lose shape. It can be cut to close tolerances for such products as gaskets, washers, channels, grommets, filters, seals, etc. It can be made waterproof and fungus-proof and flame resistant. It will pay you to place your felt requirements in the experienced hands of Western Felt. Its counsel and products will prove profitable.

Acadia Synthetic Products Division, WESTERN FELT WORKS, Processors of Synthetic Rubbers—Sheets, Extrusions, Molded Parts.

**WESTERN FELT WORKS**
4035-4117 Ogden Avenue, Chicago 23, Illinois
BRANCHES IN ALL PRINCIPAL CITIES
*Largest Independent Manufacturers and Cutters of Wool, Hair and Jute Felts*

# Steel-Weld FABRICATION



Steel-Weld Fabrication of irregular shapes, such as the gear housing cover illustrated above, is a true test of design ability, craftsmanship and production facilities. Regardless of what your requirements may be — no matter what size, shape or weight — you will find in the Mahon organization an unusual source for welded steel in any form . . . a source with complete production and machining facilities, backed by a staff of competent design engineers and highly skilled workmen from whom you may expect a smoother, finer appearing job, embodying every advantage of Steel-Weld Fabrication.

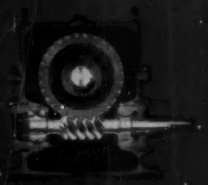
THE R. C. MAHON COMPANY
DETROIT 11, MICHIGAN

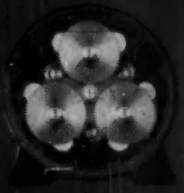
*Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products*

# MAHON

*Your kind of . . .*

# SPEED REDUCERS





When you want a speed reducer you want the type that will best handle your particular drive problem . . . and you want a reducer that will "stand the gaff." Jones reducers measure up to both of these standards.

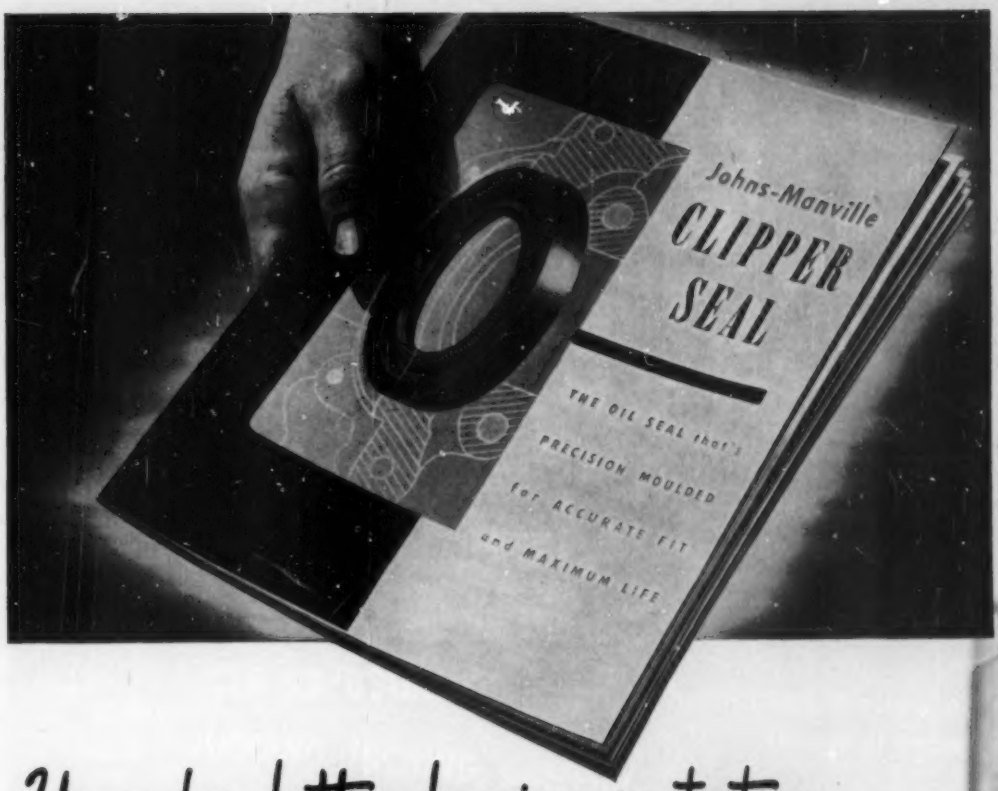
It makes no difference whether you require herringbone, spur or worm gear reducers, the Jones organization can give you just what you need in any ratio and capacity . . . and over the years Jones reducers have shown the ability to "take it" under the most severe operating conditions.

Jones offers your kind of speed reducers to solve your kind of drive problems.

**W. A. JONES FOUNDRY & MACHINE CO.**
**4417 Roosevelt Road, Chicago 24, Ill.**

**Jones**

HERRINGBONE — WORM — SPUR — GEAR SPEED REDUCERS
PULLEYS • GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • FLEXIBLE COUPLINGS




# *Yours for better bearing protection*

## —this new book about OIL SEALS

Here is a book filled with engineering data about oil seals that you're sure to want for your files. It gives the complete story of the Johns-Manville Clipper Seal . . . tells how this precision oil seal with the one-piece moulded body is providing better bearing protection at lower cost in many types of applications.

Here you will find photographs and diagrams of typical Clipper Seal installations; information on the various lip designs that provide a choice of bearing surfaces; the wide range of sizes that are available; the thick or thin flanges that increase design freedom and permit important economies in compactness and machining tolerances.

Here are Clipper Seals that overcome the problems of electrolysis and corrosion; that can be used for dry sealing . . . or against acid fumes . . . seals designed for high temperatures and pressures . . . and for other special conditions.

If you are a design or drafting engineer, don't miss sending for your copy of this new book on Clipper Seals and their uses. It's full of practical, new ideas that may save you, your company, and your customers time and money. Write today or fill in the coupon.

**Johns-Manville**
**CLIPPER SEALS**

Johns-Manville PE-3
Box 290, New York 16, N. Y.
Please send me the new Clipper Seal Book (PK-46A).

Name_____

Company_____ Position_____

Address_____

City_____ State_____

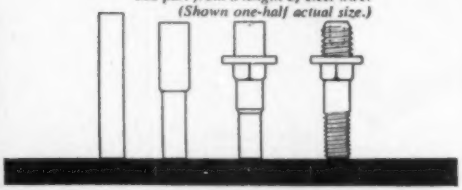
this complex shape is being made at low cost by...

*actual size*

# Cold Heading

This special steel stud, used in heavy duty power transmission equipment, combines two different shapes with four diameters.

*Some of the steps involved in cold heading this part from a length of steel wire. (Shown one-half actual size.)*



Production of this steel part by ordinary methods would involve the use of high cost machines, plus other costly operations. Cold heading not only provides economy and speed of production, but also produces a much stronger part.

Possibly this special technique can help *you* with your fastener problems. Send your sample or blueprint to Scovill *first*.

**"Guide to the Profitable Use of Cold Heading"—Bulletin No. 2 describes the advantages and limitations of this process. It's free for the asking.**

A PRODUCT OF SCOVILL

Recessed Head Screws • Sems • Tapping Screws
Standard Machine Screws • Special Cold Headed Parts

**SCOVILL** FASTENERS AND SPECIAL PARTS

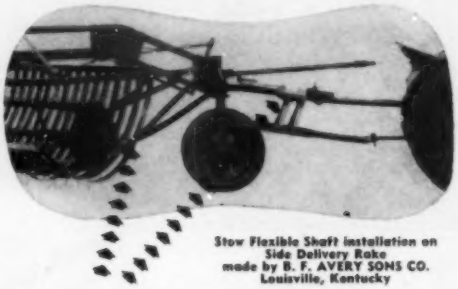
INDUSTRIAL FASTENER SALES, WATERVILLE DIVISION
SCOVILL MANUFACTURING CO., WATERVILLE 14, CONN.

New York • Detroit • Wheaton, Ill. • Los Angeles • Cleveland • San Francisco

# Design Engineers!

## Power Transmission Problems SOLVED SIMPLY

## WITH STOW Flexible Shafts



Stow Flexible Shaft installation on Side Delivery Rake made by B. F. AVERY SONS CO. Louisville, Kentucky

**•STOW FLEXIBLE SHAFTS** simplify intricate power transmission problems by eliminating complex gearing with its close tolerance and alignment difficulties.

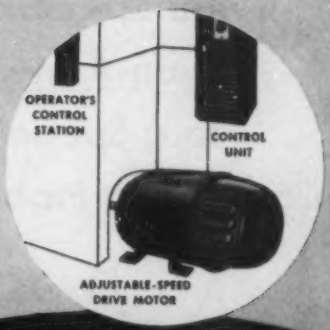
**•STOW FLEXIBLE SHAFTS** provide savings . . . increase design efficiency and eliminate hazards of exposed shaft assemblies.

**•WRITE TODAY FOR YOUR COPY OF STOW'S NEW BOOK ON FLEXIBLE SHAFTING** (included in Sweet's 1950 File for Production Designers). LEARN HOW STOW FLEXIBLE SHAFTS HAVE BEEN SOLVING POWER TRANSMISSION PROBLEMS SINCE 1875.

STOW MANUFACTURING CO.
426 State St.,
BINGHAMTON, N. Y.

# 6 REASONS

## for choosing the New Low-Cost RELIANCE ELECTRIC TRANSMISSION



STARTS without clutches!

STOPS without mechanical brakes or clutches!

REVERSES without use of gears or clutches!

SPEED ADJUSTMENTS without mechanical transmissions or change of gears!

JOGGING, INCHING, CREEPING without slipping clutches!

LOW COST — a price anybody can afford!

RELIANCE V★S DRIVE

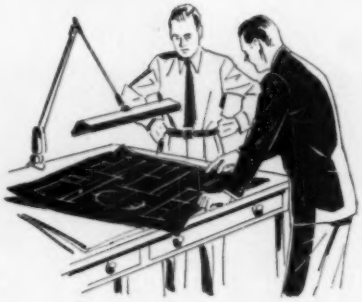
The new low-cost Reliance V★S Drive (¾ to 2 hp.) performs all the functions of mechanical transmissions — electrically! Operating from A-c. circuits, it is the ideal choice for printing presses, paper winders and slitters, packaging machines, industrial food mixers, machine tools, conveyors and many other types of equipment. Write today for Bulletin D-2101 which gives further details.

***Sales Representatives in Principal Cities***

**RELIANCE ELECTRIC AND ENGINEERING CO.**

"Motor-Drive Is More Than Power" • 1060 Ivanhoe Road, Cleveland 10, Ohio

If you are looking for an Answer to a Special Carburetion Problem...



You are looking for

# Zenith

Zenith's skill and experience have always been concentrated to one particular end—to provide the finest in specialized carburetion. Through the years Zenith has dealt with every type of engine—ranging from single cylinder lightweights to the most rugged and powerful of gasoline engines—applying 25 years of experience to the mastery of almost every conceivable carburetor problem. In engineering the individual carburetor to the specific requirements of the job, questions of placement, efficiency of performance, and economy of operation are considered from blueprint to production stage. If you are looking for the answer to a particular carburetion problem, you are looking for Zenith. Inquiries will receive prompt attention.

**ZENITH CARBURETOR** DIVISION OF

696 Hart Avenue

Detroit 14, Michigan

Bendix AVIATION CORPORATION

**MANUFACTURERS OF FINE CARBURETORS AND FUEL FILTERS**

Export Sales: Bendix International Division, 72 Fifth Avenue, New York, 11, N. Y.

# STEELBACK

## CONTACTS for welding

SILVER FACINGS INDIVIDUALLY BONDED TO STEEL

Best "Steelback" projection welding contact construction is attained by individually facing each steel disc with silver contact material. This means greater mechanical strength, and greater electrical and heat conductivity, of the joint between silver and steel.

Steel backing discs are nickel plated all over, affording improved corrosion resistance. Contact material is cold work-hardened for best wearing properties.

GIBSON'S "Steelbacks" are available with fine silver, coin silver and silver alloy facings. Monel or nickel can be supplied as the backing material where better corrosion resistance or electrical conductivity is required.

**Write today for our new folder describing Gibson "Steelback" Projection Welding Contacts.**

Gibsiloy ELECTRICAL CONTACTS

Manufactured by

GIBSON ELECTRIC COMPANY

8358 Frankstown Ave., Pittsburgh 21, Pa.

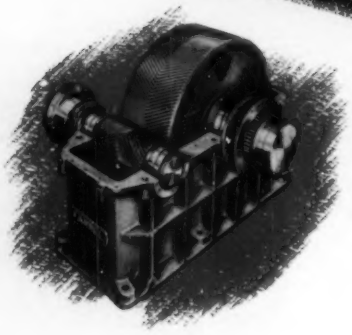
# *Twice the accuracy at a fraction of previous cost . . .*

This part, for a well-known rifle, was formerly produced by machining from a solid bar. Now it is produced as a cold drawn shape by the RATHBONE PROCESS at far greater accuracy. Furthermore, surface finish is vastly better than that of a machined part and a hard skin obtained at no extra cost. The application of RATHBONE COLD DRAWN PRECISION SHAPES instead of machined parts has been used to advantage by leading manufacturers in the metal working industry to simplify design and assembly, reduce manufacturing costs and improve products. Many shapes, difficult to produce by any other method, are made economically and precisely by the RATHBONE PROCESS. Furthermore, this process is applicable to a wide range of metals, making it possible to assure shapes of the best material for the purpose required. As pioneers in designing and producing cold drawn shapes, RATHBONE can render a valuable service in helping you improve your products. Send prints or drawings and ask for our suggestions. We can help you with your design, tooling, manufacturing and cost problems. *NOW.*

**COLD DRAWN SHAPES to your specifications—at big savings**

Ask for a copy of our new 16-page engineering bulletin covering Cold Drawn Shapes and their applications. Write TODAY!

## RATHBONE CORPORATION Palmer, MASS.



On page 5 of Farrel's latest bulletin on speed reducers, you will find a description of the *Gear with a Backbone* —the type of gear used in Farrel gear units.

The *backbone*, formed where the helices meet, makes the teeth continuous across the gear, providing extra strength and greater load-carrying and shock capacity —especially important in heavy-duty speed reducers. Precision generation by the famous Farrel-Sykes method assures accuracy of tooth spacing, tooth contour and helix angle, which pay off in smooth, quiet, uniform operation.

In addition to describing the gears, this bulletin also contains specifications, horsepower rating tables, overhung load capacities, dimensions and weights of single, double and triple reduction units.

*If you buy or specify speed reducers, you should have a copy of this informative manual. Fill out the coupon and mail it today.* FB-562

**FARREL-BIRMINGHAM CO., INC., 344 Vulcan St., Buffalo 7, N.Y.**

*Plants:* Ansonia and Derby, Conn., Buffalo, N.Y.
*Sales Offices:* Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Cleveland, Detroit, Chicago, Los Angeles, Tulsa, Houston

**FARREL-BIRMINGHAM COMPANY, INC.**
**344 VULCAN STREET, BUFFALO 7, N. Y.**

Please send me, without cost or obligation, a copy of Bulletin 449, "Farrel Speed Reducers." PE

Name..... Title.....

Company.....

Address.....

City..... State.....

*Farrel-Birmingham* ®

## How to make planned assembly savings pay off

*ASSEMBLY COSTS CUT 45%. G-M Laboratories, Inc. directly compared fastening costs before setting up assembly operations on this Skan Projector, found machine screw fastenings would cost almost twice as much as the P-K method. Four Hex Head Type Z Screws are used, together with 10 Type F and 4 Type U Drive Screws. G-M wisely planned assembly savings by choosing Self-tapping Screws; insured these savings by specifying P-K.*

## Don't let screw failure cancel savings

TYPE F
(Also made with Phillips head)

Three steps are needed to *insure* assembly savings. First, engineer your assembly for minimum cost. Next, select the simplest, speediest fastening method. Then, if as in most cases, you find this to be with Self-tapping Screws, use the best that money can buy. For, if screws run offsize, if they break or otherwise fail, all your carefully *planned* savings are lost.

## Choose P-K Screws ... avoid slowdowns and scrapped parts

**NEED SPECIAL SMALL SIZE PHILLIPS HEAD SCREWS?**

P-K Type A or Z, in No. 0 or 00 diameter, with a No. 0 Phillips Recess, can be made to order, quantity permitting.

Parker-Kalon, originators of Self-tapping Screws, learned long ago how to keep hardness and toughness properly balanced in *every* screw—learned to maintain the uniform quality that keeps assembly humming. And there's no substitute for 35 years experience.

Remember, the actual cost of screws depends, never on price, *always* on performance. Specify Parker-Kalon, and you'll see why the makers of thousands of the nation's best known products say—IF IT'S P-K . . . IT'S O. K.!

Parker-Kalon Corporation, 200 Varick St., New York 14, N.Y.
Sold everywhere through accredited Distributors.

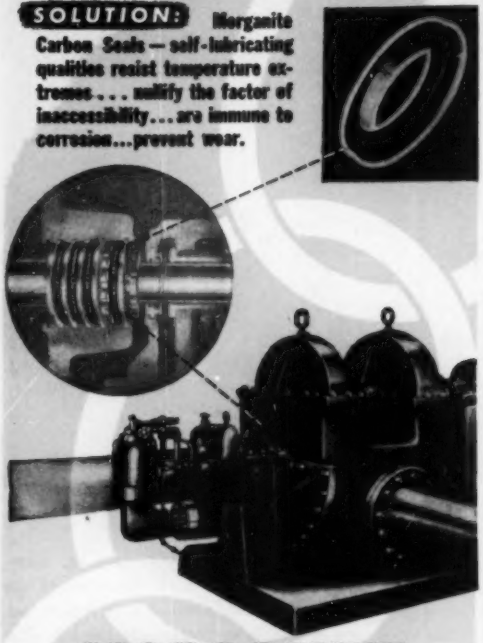
*TRADE MARKS REG. U. S. PAT. OFF.

P-K TRADE MARK

*The Original*
**PARKER-KALON* SELF-TAPPING SCREWS**
A TYPE AND SIZE FOR EVERY METAL AND PLASTIC ASSEMBLY

**PROBLEM:** Provide a seal for turbines that will hold high pressure live steam...resist corrosive forces...function without conventional lubrication.

**SOLUTION:** Morganite Carbon Seals — self-lubricating qualities resist temperature extremes... nullify the factor of inaccessibility... are immune to corrosion...prevent wear.



# MORGANITE

**SELF-LUBRICATING, HIGH PRESSURE**

## SEALS, RINGS and WASHERS

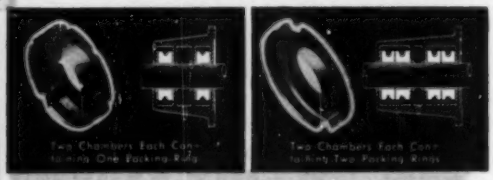
The successful application of self-lubricating seals in high pressure lines is another example of the basic advantage of Morganite Dry Lubrication — an inherent lubrication that equals the life of the seal without renewal. Full retention of steam, from cold start to full-load high temperatures, is assured. Surface scoring, which opens the way for rapid surface erosion by live steam, is eliminated.

SEE OUR CATALOG IN SWEETS FILE

For detailed information consult the Morganite Catalog in Sweets File for Product Designers; for engineering counsel, call Morganite

REGISTERED TRADE MARK Morganite INCORPORATED

LONG ISLAND CITY 1, NEW YORK




Manufacturers of Morganite Carbon Brushes for all motor and generator applications, and Morganite Carbon Piles.

# ELIMINATE COSTLY FLOW FAILURES with MAGNATROL SOLENOID VALVES

- Quick Operating
- Non Sticking
- Tight Seating

These three design advantages are your assurance against costly flow failures. Attain dependable, accurate, automatic or remote control of liquids or gases with Magnatrol Valves. You can install them quickly and easily in connection with . . . flow-meters, thermostats, float and time switches. *Every* Magnatrol Valve is delivered to you — factory tested and guaranteed free from defects in material and workmanship.

Available in normally closed or normally open models. Pressure ranges from zero up to 500 PSI. A.C. to 575 volts, 25, 50 or 60 cycles. D.C. to 250 volts.

**FREE CATALOG!**

Write today, Att: E. W. Brockman, for complete illustrated literature, containing specifications, sizes and dimensions

## MAGNATROL VALVE corp.

HAWTHORNE 5, NEW JERSEY

# F & H WHEELS

*for*

## AGRICULTURE *and* INDUSTRY

FRENCH & HECHT DIVISION

KELSEY-HAYES WHEEL COMPANY

DAVENPORT, IOWA

*Wheel Builders Since 1888*

# DIE CASTING tunes in on...

## increased output
## lower production costs
## better products

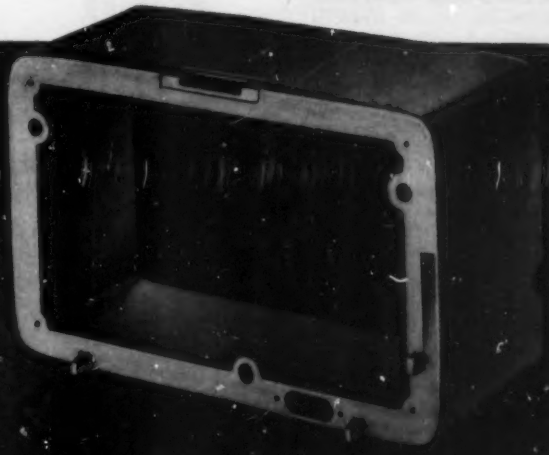
CASE HISTORIES FROM MT. VERNON FILES

The main housing for a new AC-DC-Battery portable radio posed a problem for the Garod Electronics Corporation. A sheet metal stamping was considered. This involved drawing, forming and punching, plus assembling of component parts. Lugs for hinges required riveting. After careful consideration, this construction was deemed impractical.

Die casting, therefore, was specified. Die cast in one piece, the housing is completely rigid. The entire unit, including apertures, bolt holes and lugs for hinges, is obtained in one production operation—as the die closes. And Mount Vernon supplies the casting so "clean" that it goes straight to the assembly bench without additional machining.

Yes, innumerable examples such as this prove that die casting is able to speak for itself—show you the way to increased output, superior products, lower unit costs. Whatever the item you manufacture, why not consult with us? We have a wealth of experience and specialized know-how. You may profit "to beat the band!"

MT. VERNON DIE CASTING CORP.
MT. VERNON NEW YORK



No. 37—Product of Westinghouse Electric Corp. Sharon, Pennsylvania

*Record of*

## Chace Bimetal-equipped Westinghouse Transformer Circuit Breakers

Here's proof of Chace dependability. Field performance records of over 4,000,000 Westinghouse "CSP" Transformer-Years of service on units equipped with Westinghouse circuit breakers, show that operation has been over 99.9% free of any trouble! Actuating element of the breaker is the Chace Thermostatic Bimetal stamping shown.

Our customers know us as producers of thermostatic bimetal in strips, coils or in the finished piece. Important to the user of bimetal, however, is uniform processing during *fabrication*. Bimetal requirements are such that the fabricator must be thoroughly familiar with their applications. Many customers, such as Westinghouse, take advantage of our extensive facilities for suppiying stamped, machined or assembled bimetal elements. This assures absolute precision control through the entire manufacture of control components for their products.

If the actuating element for *your* control device is thermostatic bimetal, Chace can furnish it completely fabricated—ready for assembly. Your bimetal requirements can be determined easily and quickly by consultation with our engineering department. We are completely equipped to serve you, and invite your inquiry.

**W. M. CHACE CO.**
*Thermostatic Bimetal*
1607 BEARD AVE., DETROIT 9, MICH.

● Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

**IMPERIAL PENCIL TRACING CLOTH**

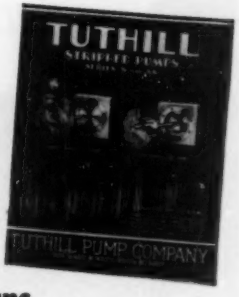
SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE

# how to save space, material and money

**By Using**

**TUTHILL**

**Stripped Pumps In Your Machinery Designs**

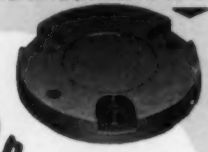



You'll find many practical suggestions for incorporating the pump directly into the design of your equipment in this Tuthill Stripped Pump bulletin. It presents the two types of stripped pumps available, designed for lubrication, coolant, hydraulic and liquid transfer service. Capacities up to 200 g.p.m. Send for your copy today.

**TUTHILL PUMP COMPANY**
939 East 95th Street . Chicago 19, Illinois . Phone RE 4-7420

ON GOOD APPLIANCES
DELCO PREFERRED
FOR GOOD REASONS
Appliances give the best service when they are powered by the best motors. Year after year Delco motors prove their lasting quality on millions of appliances.
But appliance manufacturers want even more than quality from their motor supplier. In a fast-changing market they may need to make last minute changes in motor specifications or delivery dates.
Because Delco motors combine quality of product with flexibility of supply, more and more spec sheets carry: "DELCO PREFERRED." Dependable Delco appliance motors, designed to meet the specific torque and service requirements of the application, are built in sizes from 1/8 h.p. up.
√ √ √
Why not get all the facts about Delco motors? Contact the nearest sales office listed below—
DELCO MOTORS
DELCO PRODUCTS
Division of General Motors Corporation
Dayton, Ohio

In producing this pump flange, Powdermet production saved 400%!



# Price

## IS THE ONLY DIFFERENCE!

Powdermet makes this governor weight cost only 1/10 as much as before!

**POWDERMET* PARTS**

## Cost Less!

"Matched pairs" like these... actual production parts, one produced by conventional methods and one Powdermet, identical in precision and performance...prove the amazing economies made possible through Powdermet fabrication. And when special properties like electrical permeability or controlled porosity are important, Powdermet parts offer functional advantages too! Exclusive Powdermet production techniques have extended the application of powder metallurgy to whole new production fields—helical gears, stress members, filters—write today for the free booklet shown here and see how you can save with Powdermet parts!

**SEND FOR THIS FREE BOOKLET**

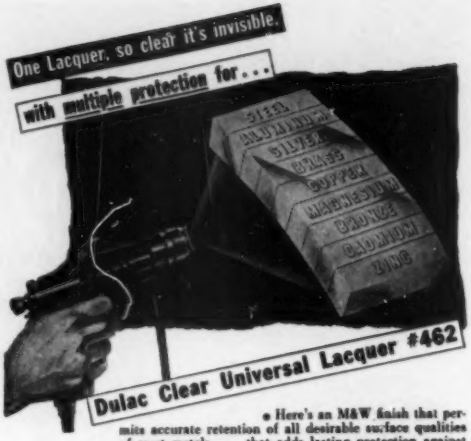
Check Powdermet advantages for your gears • filters • cams • pole pieces • ratchets • tuning cores • keys • latches • bearings • pawls • sprockets • valves • switch parts

**PMP**

**POWDERED METAL PRODUCTS CORPORATION of America**

9335 West Belmont Avenue
Franklin Park, Illinois

*Trademark




• Here's an M&W finish that permits accurate retention of all desirable surface qualities of most metals . . . that adds lasting protection against heat, cold, weather, corrosion, stain and perspiration — Dulac Clear Universal Lacquer #462. It's formulated to give good adhesion with either the spray, dip or brush method. And it fits into fast production schedules because in five to ten minutes this successful general purpose lacquer dries out of dust . . . hardens in one hour. For complete information, write for Technical Data Bulletin 110 or let an M&W technical consultant discuss your requirements privately with you.

*...where industry goes with finishing problems*

**MAAS & WALDSTEIN COMPANY**

Newark 4, N. J. • Chicago 12, Ill. • Los Angeles 24, Calif.

Pacific Coast Distributor: SMITH-DAVIS CO., 10251 Venice Boulevard, Los Angeles 34

MANUFACTURERS OF INDUSTRIAL FINISHES

## Don't take less than a *Leach* for Unsurpassed Performance

LEACH RELAY CO. offers a wide range of control relays of standard types; and stands ready to link new designs to your specific needs. Highest standards of engineering, materials and workmanship assure long, safe, efficient, trouble-free service.

*FOR BETTER CONTROLS THROUGH RELAYS—CONTACT LEACH*

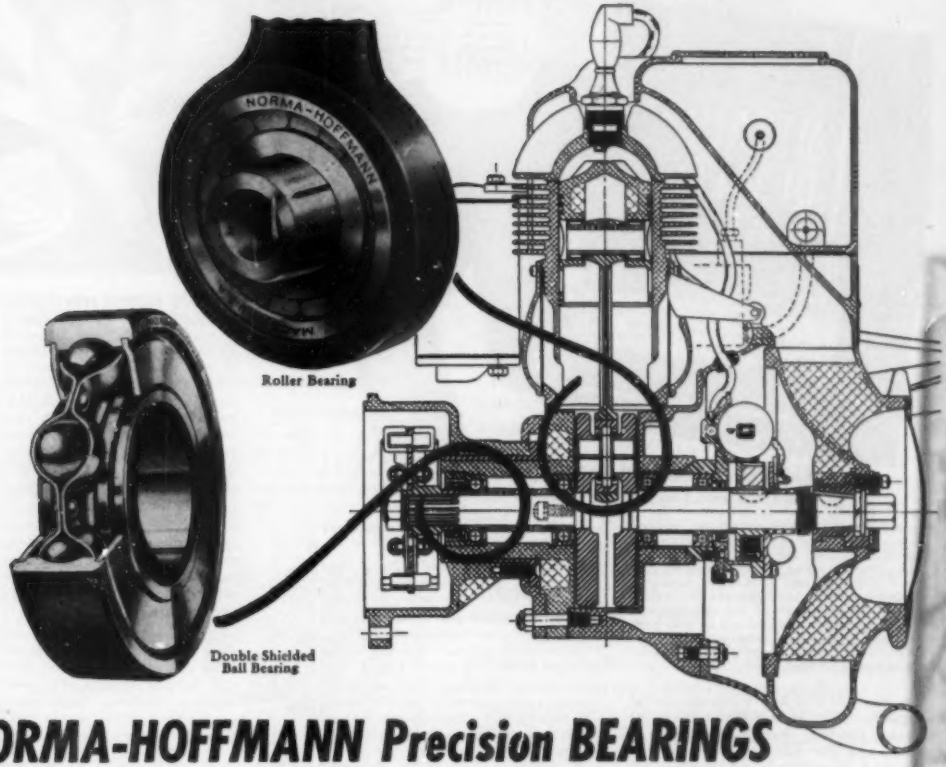
**LEACH RELAY CO.**

5915 AVALON BOULEVARD • LOS ANGELES 3, CALIF.

*Representatives in Principal Cities of U.S. and Canada*

ANOTHER
"Preference-Proof"
STORY:

# Mall Chain Saws have SOMETHING EXTRA to OFFER




## NORMA-HOFFMANN Precision BEARINGS

Whether it is a sapling or a giant redwood, you simply step up to the tree with a Mall Chain Saw and it is T-I-M-B-E-R almost at the word go.

Mall engineers, like other leading designers, use Norma-Hoffmann Precision Bearings in their gasoline engine Chain Saw for dependable performance. They know that these bearings *add an extra* to the product with long life and low upkeep.

Mall uses a roller bearing at the lower end of the connecting rod, the crankshaft rotates on four single shielded ball bearings. A double shielded and single shielded ball bearing is used in the transmission. Idling speed of the engine is 1600 rpm. . . . working speed under load is 4500 rpm. . . . maximum speed under no load is 5000 rpm.

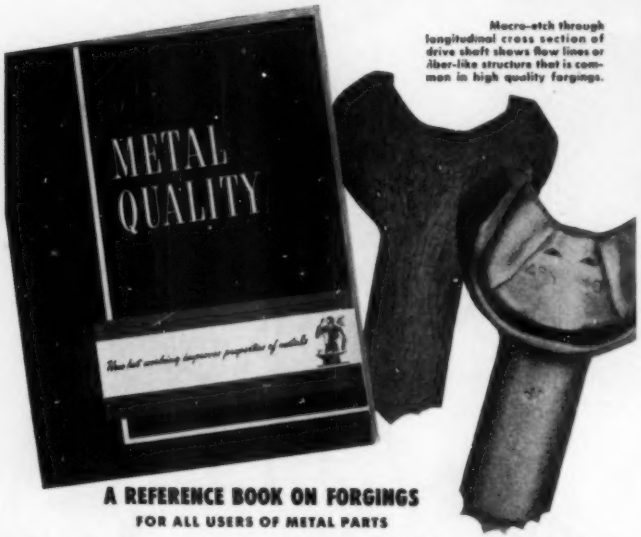
You, too, can add an *extra something* to your products with Norma-Hoffmann Precision Ball and Roller Bearings. Write for catalog and engineering assistance.

**NORMA-HOFFMANN**
*Precision* **BEARINGS**
BALL • ROLLER • THRUST

**NORMA-HOFFMANN BEARINGS CORPORATION**
Stamford, Connecticut

Field Offices: Cincinnati • Cleveland • Detroit • Chicago • Dallas • Phoenix • Los Angeles • San Francisco • Seattle

# FORGINGS PROVIDE MATCHLESS CAPACITY FOR THE TOUGHEST WORK LOADS




Macro-etch through longitudinal cross section of drive shaft shows flow lines or fiber-like structure that is common in high quality forgings.

## A REFERENCE BOOK ON FORGINGS

**FOR ALL USERS OF METAL PARTS**

Sixty pages of authoritative information on metal quality as developed in forgings formed through the use of closed impression dies. Forging production techniques are described and illustrated; economic advantages of forgings are presented from the viewpoint of top management, design engineers, metallurgists and production executives. Your copy is ready. Fill in and attach coupon below to your business letterhead.

* * *

A product fortified with the metal quality found in forgings outperforms other products. Forgings' grain structure and fiber-like flow lines are controlled, directioned, and concentrated at points where the highest stress and shock occur under actual service conditions. High tensile and impact strength, the reduction of dead weight, and freedom from concealed defects are some of the advantages which are obtainable in forgings.

Now is an excellent time to check your product for cost reductions—explore every possibility to improve performance and appearance, while reducing dead weight of component parts. Double check all parts subject to the greatest stress and strain. Check machining and finishing time schedules—forgings have been known to speed up production by 250 per cent. Rejects at the point of assembly are costly—a needless waste; forgings offer practically a 100 per cent yield of sound parts—and they respond uniformly to heat treatment. Consult a forging engineer—only a forging engineer can inform you fully regarding the many advantages obtainable with forgings.

**DROP FORGING ASSOCIATION**
605 NANNA BUILDING
CLEVELAND 15, OHIO

Please send 68-page booklet entitled "Metal Quality—How Hot Working Improves Properties of Metal", 1949 Edition.

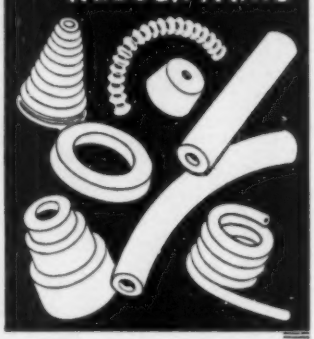
Name .....

Position .....

Company .....

Address .....

# SILICONE RUBBER PARTS



**WITHSTAND EXTREME TEMPERATURES RANGING FROM —160° to +500° F.**

**SILICONE RUBBER PARTS** play important roles in automotive, aviation, electrical, refrigeration, and original equipment manufacturing industries because they retain desirable rubber-like properties at temperatures from −160° to +500°.

**SILICONE RUBBER PARTS** resist permanent compression, have excellent dielectric properties, and withstand hot lubricating oils, Freon, liquid ammonia, sulphur dioxide, ozone, tricresyl phosphate, and chlorinated hydrocarbons.

**SILICONE RUBBER PARTS** can replace metal constructions forced upon design engineers by limited thermal stability of organic rubbers. Gaskets, diaphragms, grommets, washers, sleeves, channel, packing, tubing, and numerous other molded, extruded, punched, and lathe-cut products can be fabricated from Silicone stocks.

Write today for complete information or quotations.

**STALWART RUBBER COMPANY**

*Specify Stalwart for Quality Custom Rubber Products*

3166 Northfield Road
BEDFORD, OHIO

# Reduce Costly Motor Failures!

# TOUGH WINDINGS

## give Electro Dynamic motors money-saving stamina... trouble-free dependability

**E. D. DRIP PROOF INDUSTRIAL MOTOR.** For use under ordinary industrial conditions not requiring protection from splashing liquids or from atmosphere laden with dirt or metal chips.

SPLASH PROOF
For installation where the motor is subjected to splashing liquids or hosing down for cleaning.
TOTALLY ENCLOSED (Fan Cooled)
For use in dirt-laden atmospheres, especially where the installation requires a motor of compact dimensions.
TOTALLY ENCLOSED (Non-Ventilated)
For use in exceptionally dirty atmospheres, particularly when metallic dust is present.

*Also a Complete Line of* **DIRECT CURRENT** *Motors and Generators. Literature on Request.*

Now you can cut down electric motor failures—so costly in down-time and repair expense.

Electro Dynamic industrial motors assure you actually much longer service and sure-fire, trouble-free operation—because they have *extra* stamina. They're tough where motors should be tough—at the windings.

Half a century ago, Electro Dynamic began building electric motors for submarines. As submarines developed and cruising ranges increased tremendously, E. D. *windings*—"the heart of the motor"—had to be made tougher and tougher to keep pace with the requirements of gruelling undersea service. Thus special skills and superior insulating materials now go into E. D. windings to give E. D. motors the added strength, endurance, and vital dependability needed aboard subs and the many new ships equipped with E. D. power.

Today you can benefit from these great advances in electric motor manufacture. For E. D. *industrial* motors inherit all the qualities of toughness, long life, and dependable performance that have been developed for the famed sea-going units.

E. D. industrial motors are built in a wide range of types and sizes—1 to 250 h.p., A.C. and D.C. It will pay you well—and cost you nothing—to get all the facts on E. D. motors. Write today for illustrated literature.

ELECTRO DYNAMIC

Industry has learned what marine engineers have known since 1880

**ELECTRO DYNAMIC • Division of the Electric Boat Company • Bayonne, N. J.**

*DEPENDABLE! Makers of timing devices of all kinds tell us that SYNCHRON motors can be depended upon for sustained accuracy and trouble free service under all working conditions*

## SYNCHRON MOTORS

**Never Need Oiling—**
**Operate Efficiently**
**In Any Position—**

Motor is equipped with oil storage reservoir and patented oil feed to bearings. Rotor shaft, reduction train, and output shaft, all have double bearings to reduce vibration and assure quiet, efficient operation when mounted in any position.

## SYNCHRON MOTORS

**Are Thoroughly Tested**

More than three million of these miniature timing motors are now in use . . . many of them for many years. Each motor is tested carefully to rigid operation standards before it leaves our factory. We make no compromise for quality!

**Get the Facts about**

## SYNCHRON MOTORS

Send for complete engineering data on SYNCHRON synchronous, self-starting motors and time machines. Fill in, tear out, and mail this coupon:

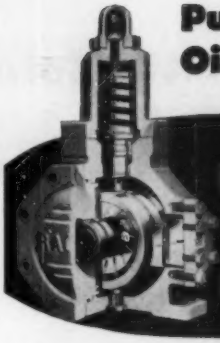
**HANSEN MFG. CO., INC.** (3-50)
**Princeton 5, Indiana**

Please send data checked below:

Catalog on SYNCHRON MOTORS, Time Machines, and Clock Movements.

We attach outline of a special timing problem. Let us have your suggestions without obligation.

Name .....
Position .....
Company .....
Address .....
City ..... State .....



## Put ALL of the Oil to Work

**RACINE**
*Variable Volume*
**PUMPS**

VISIT OUR BOOTH NO. 22
Commercial Museum
CONVENTION HALL, PHILADELPHIA, PA.
APRIL 10 to 14

**Simplify the Circuit and Improve Its Efficiency**

Use RACINE Variable Volume Pumps; they automatically deliver only the exact volume required. Relief valves are eliminated. Heating is reduced, horsepower saved. Over-all cost of circuit components is less. These advantages are yours when you "put all of the oil to work."

The RACINE Line is complete. Pumps to 30 G.P.M. Pressure Boosters to 5000 P.S.I. Balanced piston sleeve-type 4-way valves, straight-way valves and controls, all designed for manual, electric or hydraulic operation. Complete factory and field engineering service without cost.

*Write for Catalog P-10-D. Address Racine Tool and Machine Co., 1772 State Street, Racine, Wis.*

**RACINE**

STANDARD FOR QUALITY AND PRECISION

*To help you*
**design basic parts for quantity production**
*more economically and quickly*

THIS practical book covers the design of basic parts for quantity production by die casting, sand casting, screw machine, stamping, die forging, hot and cold heading and plastic molding. Along with full explanations of the various high-production processes, you get many specific rules, amply illustrated to show their practical applications for designing products that lend themselves to rapid and economical mass production.

## HANDBOOK ON DESIGNING for QUANTITY PRODUCTION

Prepared and Edited by HERBERT CHASE

**517 pages • 351 illustrations • $5.00**

NOW you can avoid the necessity for redesign. Not only will you be able to form the original design quicker, but you can be sure to make it more suitable to economical production in large quantities. Use the book once for an invaluable design pointer on materials . . . for exact design considerations . . . or for one of the straight-forward rules to follow in designing basic parts for the different quantity production processes. Use it once, and then decide whether this book will remain right at your fingertips for instant reference.

**Try the book for 10 Days FREE!**
Mail Coupon NOW!

McGraw-Hill Book Co., 330 W. 42d St., NYC 18

Send me Chase's HANDBOOK ON DESIGNING FOR QUANTITY PRODUCTION for 10 days' examination on approval. In 10 days I will send $5.00, plus a few cents for delivery or return the book. (We pay for delivery if you remit with this coupon; same reutrn privilege.)

Name .....
Address .....
City ..... Zone..... State.....
Company .....
Position ..... FIVE-8-50
Books sent on approval in U. S. and Canada only

Job File No. 194

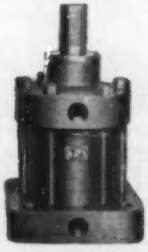
## MALLEABLE NUT PRODUCTION

# *Fully Automatic*

## CONTROLLED BY T-J CYLINDERS

All moving parts are controlled hydraulically by T-J Cylinders —on this Malleable Nut Production Machine designed and built by Roy Hays & Associates, Rockford, Ill., for the Wagner Malleable Products Co., Decatur, Ill.

It's *fully automatic*—the operator only places nuts in stations. Nine T-J Cylinders, 40 ton to ½ ton, help complete the job of cutting off sprue, sizing, boring, facing, chamfering and threading 2,500-¾ std. pipe thread nuts per hour.



For your tough jobs of power movement —pushing, pulling or lifting—*save labor, speed production* and *cut costs* with T-J Air and Hydraulic Cylinders! Many standard sizes and styles . . . both cushioned and non-cushioned types . . . 100 lb. or 50,000 lb. Precision-built for long-life dependability. Write for latest catalogs. The Tomkins-Johnson Co., Jackson, Michigan.

FOR POWER MOVEMENT IN ANY DIRECTION

100 LB. or 50,000 LB.

32 YEARS EXPERIENCE

T-J

**TOMKINS-JOHNSON**

RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHORS

✓ Check

# R-B-M INDUSTRIAL CONTACTORS *NOW!*

Underwriters' Approved. 600 Volts AC

✓ **SIZE**

***Non-Reversing***

2 to 4 Pole 2-3/4" w. x 3-5/8" h. x 3-5/16" d.
5 to 8 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.

***Reversing***

2 to 4 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.

Note: 10 and 15 ampere contactors have same mounting and overall dimensions.

✓ **ACCESSIBILITY**

To replace contacts, it is not necessary to disassemble the complete contactor. Just remove the parts comprising the stationary and movable contacts. Contacts can be replaced without disturbing wiring. To change coil, remove magnet frame and coil assembly only. (See illustration below.)

✓ **FLEXIBILITY**

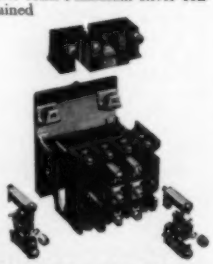
Using a screw driver only, you can easily change any pole from normally open to normally closed. No special parts required. 10 and 15 ampere parts are interchangeable.

✓ **RELIABILITY**

Laboratory tests involving millions of operations, plus field service of thousands of R-B-M contactors on door operators, radio transmitters, packaging and weighing machinery, hoists, machine tools and many other industrial applications offer proof of dependable, trouble-free performance.

✓ **ADVANCED DESIGN**

Melamine Insulation. Molded coil housing. Ilsco solderless connectors. 50/60 cycle magnet coils. Palladium silver contacts. Stainless steel self-contained contact springs.



Where space is a factor, and accessibility a must—use R-B-M industrial contactors. Initial low cost plus dependable performance will save you money. Write for Bulletin 600 and price list on your company letterhead.

Dept. C-3 R-B-M DIVISION OF ESSEX WIRE CORP.
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE INDUSTRIAL COMMUNICATION AND ELECTRONIC USE



They LOOM LARGE in an Efficient Production Schedule

U. S. PAT. No. 2054189

# MIDLAND WELDING NUTS

5/8" F-2016-A

1/2" F-2012

3/8" F-2008

5/16" F-2006

1/4" F-2004

- Self locating, assuring accuracy and rapid assembly without locating pins or fixtures.

Reduce inventory. Midland Welding Nuts can be used on a wide variety of metal thicknesses, eliminating different heights of collars.

Offer many other advantages. Write, wire or phone for complete information.

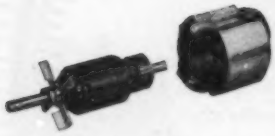
## The MIDLAND STEEL PRODUCTS CO.

6666 Mt. Elliott Avenue • Detroit 11, Michigan

WORLD'S LARGEST MANUFACTURERS OF AUTOMOBILE FRAMES—

# use of a Lamb Electric special application MOTOR

## Instead of a Standard Frame Motor Can Result in up to 6 ADVANTAGES....



Universal motor parts widely used in small portable electric tools, sewing machines, and hand vacuum cleaners.

Series universal motor parts for such applications as portable business machines and many types of household appliances.

Compensated series universal motor parts used in many types of heavy-duty industrial applications.

As you explore the various possibilities of reducing costs, improving your product, or both, it will pay to look into the advantages of a Lamb Electric *special application* motor.

A Lamb Electric Motor — engineered for the exact requirements of your application — will provide:

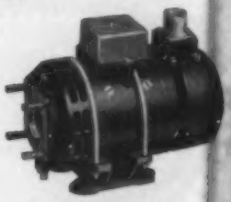
**IN THE MOTOR...**

1. Reduced cost, weight, space.
2. Exact mechanical and electrical characteristics.
3. Thorough dependability.

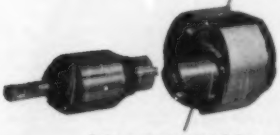
**IN THE PRODUCT...**

4. Better performance.
5. Improved eye-appeal.
6. Compactness, less weight.

Our experience in designing and building motors for over three thousand different applications is available to help you obtain these results. *The Lamb Electric Company, Kent, Ohio.*

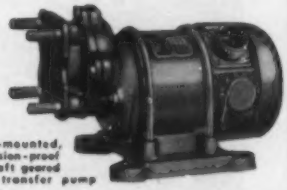


Aircraft hydraulic pump motor with maximum output, minimum weight. Adaptable to many heavy-duty industrial applications.



Series motor parts used for such applications as household appliances and light-duty portable tools.

Universal motor used for commercial vacuum cleaners, wheel balancers, air compressors, etc.



Base-mounted, explosion-proof aircraft geared fuel transfer pump motor.

**THEY'RE TEAMING UP WITH AMERICA'S *Finest* PRODUCTS . . .**

# Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

**SELL MORE**— You have an advantage against competition when the various components of your product rank high in quality. They provide the necessary stimulus to increased sales. For instance, if heat transfer is a factor in your product, perhaps you too can use Wolverine Trufin* instead of plain tube. You'll see a great difference in efficiency. Trufin, as you know, is the finned tube with the fins integral with the tube itself, and therefore can withstand vibration and sudden temperature changes without impairing heat transfer qualities.

**SAVE MORE**— The use of Trufin will save more space and labor cost. The ratio of outside diameter to inside diameter is often as high as 20 to 1. Such reductions make for smaller, more compact and usually more efficient operating units, which in turn also make for fewer components and less materials used, as well as savings in labor in assembly.

**STRIVE FOR**— lower break-even points—for lower costs in construction and assembly—for better products with longer life—for sharper reductions in maintenance and replacement costs.

**SEND FOR** . . . more complete information about Wolverine Trufin*—about available sizes, alloys and fin forms. We invite you to discuss your technical tubing problems with our engineers.

*REG. U.S. PATENT OFFICE

*Wolverine Trufin and the Wolverine Spun End Process available in Canada through the Unifin Tube Co., London, Ont.*

**WOLVERINE TUBE DIVISION**

Calumet & Hecla Consolidated Copper Company

*MANUFACTURERS OF SEAMLESS, NON-FERROUS TUBING*

**1415 CENTRAL AVENUE • DETROIT 9, MICHIGAN**

PLANTS IN DETROIT AND DECATUR, ALA.

Sales Offices in Principal Cities

# It PAYS to work with an MB Vibration Exciter

**You can save time, eliminate tedious calculations, and improve your product with the help of an MB electromagnetic shaker. Note how these benefits add up in the following typical applications – just three of many uses for this quality-control and research "tool."**

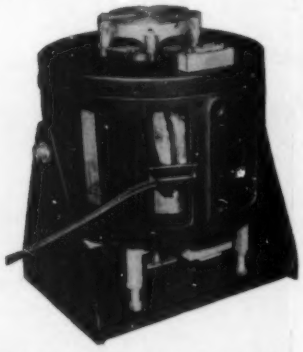
**MODEL SA VIBRATION EXCITER** Delivers 5 pounds force from 20 to 1,000 c.p.s., usable to 20,000 c.p.s.

**INDEFATIGABLE FATIGUE TESTER** – Here is the endurance tester to show up *quickly* those faults which often result in failures under dynamic stresses. Why risk trouble reports? You can shake such parts as axles, brackets, complete assemblies, housings, castings and make improvements *before* full scale production – *before* the remedy becomes costly.

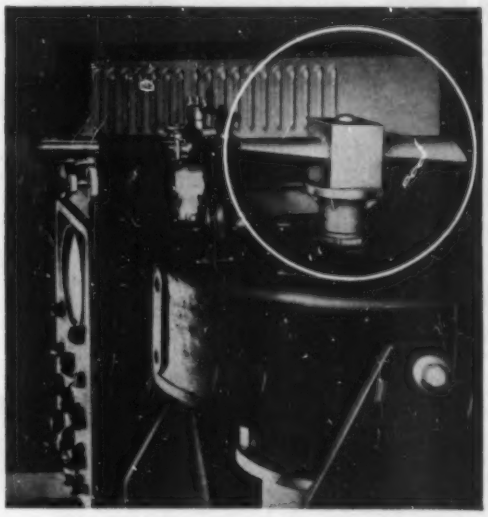
**NOISE LOCATER** – Operating silently, the MB Exciter reveals sources of noise in equipment of all types. Because you can "scan" a product's operating frequency range, you can put your finger right on resonant trouble areas. Less noise means more customer satisfaction.

**SHAKE OUT THE "BUGS"** – Electrical and sensitive components can be checked for ability to withstand severe vibratory service conditions. Reproduce the effect of years of vibration on your product within *hours!*

You'll find MB Vibration Exciters at work for many leading companies recognized for the quality of their engineering. Would you like to know how to apply one to your *own* problems? An MB engineer will be glad to show you—without obligation.



**MODEL S3 VIBRATION EXCITER** Delivers controlled force up to 200 pounds, in frequency range of 3 to 500 c.p.s.



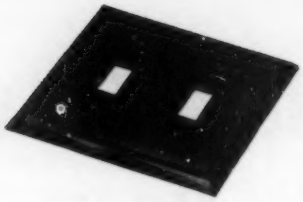
Testing of small turbine blades (encircled) mounted on an MB Model C-1 Exciter which delivers 25 pounds force in range of 4 to 500 c.p.s. (and higher). Using stroboscopic lighting, resonances and deflections are studied *visually* — and any need for corrections determined quickly. A stronger, stiffer blade is sure to result.

**DO YOU HAVE OUR NEW BULLETIN ON FILE?**

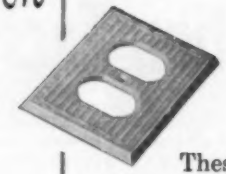
It contains helpful design data on vibration control, plus more information on the line of MB Exciters. Write for your copy today. Ask for bulletin No 410-G6.

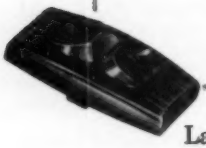
**THE MB MANUFACTURING COMPANY, Inc.**

**1060 State St., New Haven 11, Conn.**



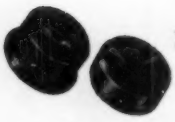
# PASS & SEYMOUR ...design for Automatic Molding



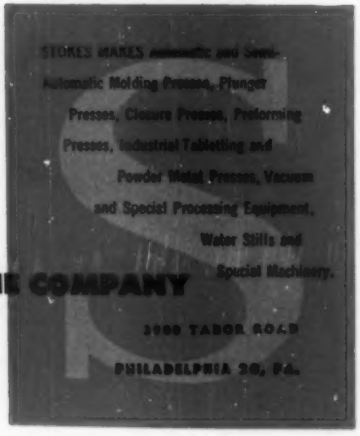


These plastic electrical parts . . . all *designed* for molding on Stokes completely automatic presses . . . are produced by Pass & Seymour, Inc., Syracuse, N. Y.

Labor and material savings are large. Inventory is geared to daily requirements. High speed, long run automatic molding is foolproof, flexible, economical. Stokes fully automatic molding presses produce superbly finished identical parts, accurate in dimension, simple or complex, thin-wall or heavy section . . . at extraordinarily low costs.



Stokes offers assistance in part and mold design, plastics material selection, and choice of molding equipment . . . all for profitable production. Blueprints or parts are welcome for impartial design-and-cost analysis.




**F. J. STOKES MACHINE COMPANY**

F. J. STOKES MACHINE CO.
5900 Tabor Road
PHILADELPHIA 20, PA.

*Please . . . a copy of Bulletin No. 500 describing the NEW Stokes No. 741 Completely Automatic Molding Press.*

NAME _____ TITLE _____

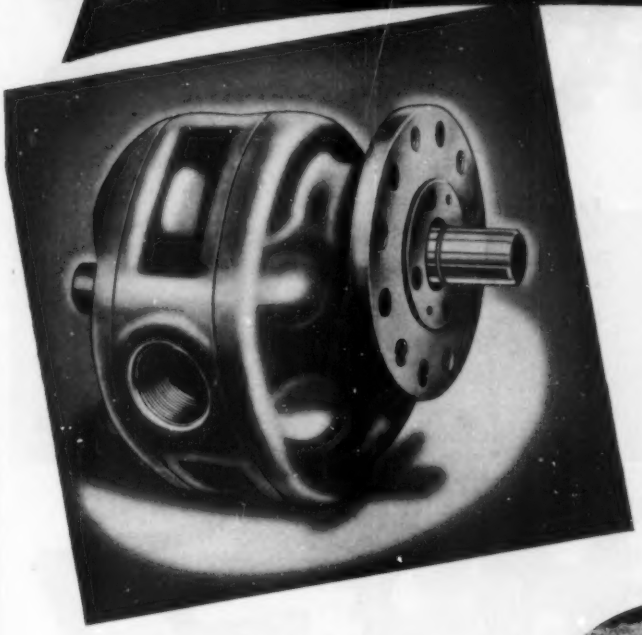
COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____ 99

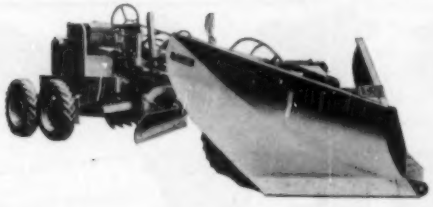
# DO YOU USE *Oil Hydraulics?*

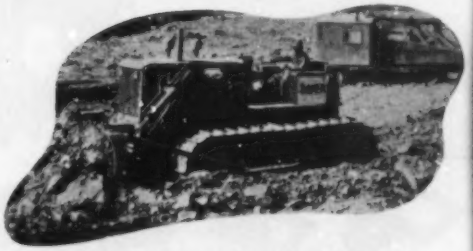
## HYDRECO GEAR PUMPS *are designed to take abuse*



Operating under normal conditions, heavy earth moving equipment and road machinery impose terrific mechanical and hydraulic loads on their hydraulic systems. HYDRECO Pumps have long been known for their ability to take this abuse and more. That's one reason HYDRECO pumps are being specified by more and more equipment manufacturers. Extra heavy housings, large area roller bearings, precision manufacturing keep HYDRECO pumps operating under even the worst conditions of shock loads, excessive speeds and poor and dirty lubricants.

HYDRECO Four-Bolt pumps also furnish dependable hydraulic power for positioning this new Model 277 Baker snow plow attachment for an Allis-Chalmers model D motor grader.





Abuse and tough service are the rule rather than the exception for this big Model 19B Baker Bulldozer manufactured by The Baker Manufacturing Company, Springfield, Illinois. Dependable hydraulic power for controlling the dozer blade is furnished by the new 3000 series HYDRECO Four-Bolt Pump.

***Quality* IN DESIGN... *Quality* IN PRODUCT**

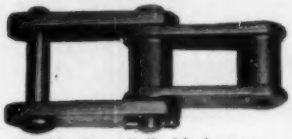
WRITE TO—

**HYDRECO**
HYDRAULIC CONTROL DEVICES
PUMPS · CYLINDERS · VALVES

**HYDRAULIC EQUIPMENT COMPANY**
1112 EAST 222nd STREET • CLEVELAND 17, OHIO

# CHAINS, SPROCKETS and ATTACHMENTS

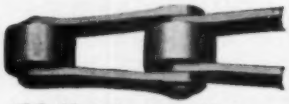
Detachable Link—Malleable Iron, SUPERMAL or PERDURO



Combination—Malleable Iron or SUPERMAL Block Links and Steel side bars.

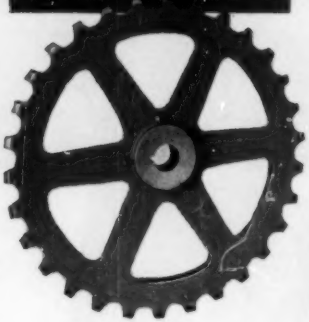
"H" Type Mill—Malleable Iron, SUPERMAL or PERDURO

"400" Class Pintle

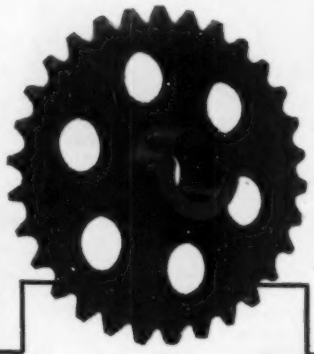


Malleable Roller—Malleable Iron, SUPERMAL or PERDURO

Steel Thimble Roller with straight or offset side bars



**For every Elevating, Conveying and Driving need. Easy to select the right type and size from the broad Jeffrey line.**



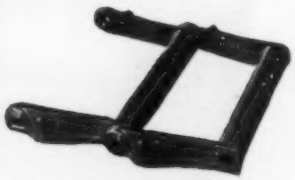
Long Pitch Steel Thimble Roller with plain or flanged rollers

"800" Class Steel Bushed

Steel Knuckle

Transfer

Steel Block in various types



"H" Type Refuse—Malleable Iron or SUPERMAL

A-1

F-2

H-2

K-2

A-42 with C-wing

G-6

S-1

# THE JEFFREY MANUFACTURING COMPANY

Established 1877

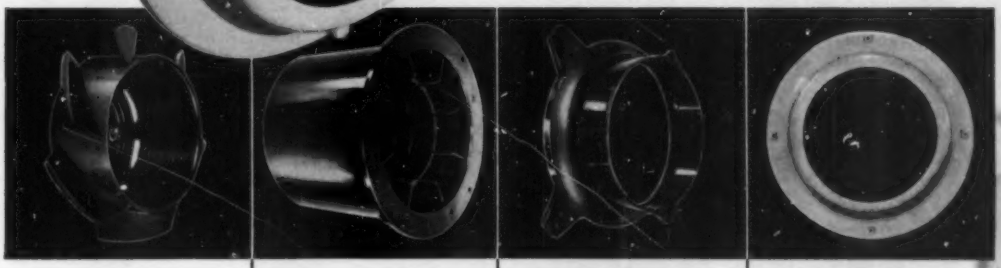
788 North Fourth St., Columbus 16, Ohio

Complete Line of Material Handling, Processing and Mining Equipment

Baltimore 2 · Birmingham 3 · Boston 16 · Buffalo 2 · Chicago 1 · Cincinnati 2 · Cleveland 13 · Denver 2 · Detroit 13 · Harlan · Houston 5 · Huntington 19 · Jacksonville 2 · Milwaukee 2 · New York 7 · Philadelphia 3 · Pittsburgh 22 · St. Louis 1 · Salt Lake City 1 · Scranton 3

Axivane Kitchen Exhaust Fan—by Joy Mfg. Co.

# A Whiz-z-z-z in PLASTICS



**one** | **two** | **three** | **four**

PERFORMANCE-WISE—in a class by itself! Production-wise — an almost classic plastics application! This Joy Axivane Kitchen Exhaust Fan has something to offer everybody. • It consists of a motor, a filter unit, a vast amount of ingenuity, and some 9 lbs. of plastics, Kurz-Kasch moulded. There's the rotor (**one**), *statically and dynamically balanced*. There's the casing (**two**) with moulded-in stationary vanes and motor mounting—*nearly 5 solid pounds of it*. There's the big plunger-moulded flared intake (**three**), engineered as a press-fit support member. They're *all* phenolic material. Then, there's the urea bezel retainer ring (**four**), 15" in diameter. Assembled, you get the only vane-axial exhaust fan on the market—quiet, non-turbulent, highly efficient and easily installed—effective not only in kitchens, but wherever volumes range from 250 cfm to 400 cfm at pressures not exceeding 0.8" w.g. • Why plastics? It's fire-resistant, acid-resistant and weather-proof. It's light for easier mounting. It's attractive cost-wise. And after months of tests, its dimensional stability has been pronounced noteworthy. • Why Kurz-Kasch? We've built our reputation on jobs like this for over well over 30 years. Jobs that we're proud of, from good design to on-time delivery. Call us and we'll do the same for you.

**Kurz-Kasch, Inc. • 1437 South Broadway • Dayton 1, Ohio**

**BRANCH SALES OFFICES:** New York, *Lexington 2-6677* Chicago, *Harrison 7-5473* • Detroit, *Trinity 3-7050* Philadelphia, *Granite 2-7484* • Dallas, *Lakeside 1022* Los Angeles, *Prospect 7503* • St. Louis, *Rosedale 3542* Toronto, Canada, *Adelaide 1377*.

**EXPORT OFFICE:** 89 Broad Street, New York City, *Bowling Green 9-7751*.

**Kurz-Kasch**

FOR OVER 34 YEARS PLANNERS AND MOULDERS IN PLASTICS

**FOR LOWER TARE WEIGHT**

Users of Wirebound Boxes and Crates consistently save 33⅓% on tare weights. In addition, Wirebounds require less storage space, are easily handled, can be set-up in less than a minute, and are ideally suited to modern warehousing.*

**FOR GREATER STRENGTH**

To assure the utmost product protection in handling and shipping, all Wirebounds are constructed to specifications developed by exhaustive laboratory and field testing. Wirebounds are designed to meet the hazards of shipment and storage of your particular product.*

**FOR FRAGILE PRODUCTS**
**FOR HEAVY PRODUCTS**

The adaptability of the Wirebound principle is demonstrated by the variety of containers shown here. Heavy products, delicate products, products of odd or irregular shapes ship safely and at lower cost in Wirebounds. Ask us for suggestions on shipping your product.*

USE

Wirebound

BOXES & CRATES

FOR LOWER TOTAL SHIPPING COSTS

60 Wirebound Plants throughout the United States

***Send for this free book** . . . contains the full Wirebound story, technical information and demonstrates how Wirebounds are specifically designed for each product. Mail coupon today!*

**Wirebound Box Manufacturers Assn., Room 1820, Borland Bldg., Chicago 3, Ill.**

☐ Send Booklet of Product Information ☐ Send a Sales Engineer

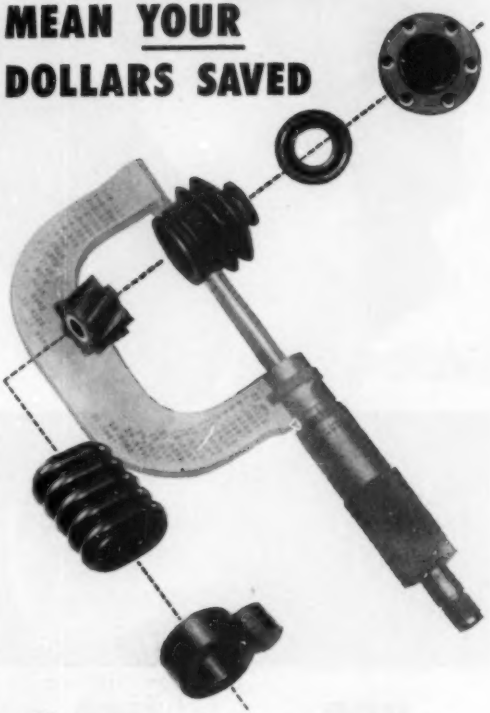
NAME

COMPANY ADDRESS

CITY ZONE STATE

OUR PRODUCT IS

# CLOSE TOLERANCES *Plus** MEAN YOUR DOLLARS SAVED



WHENEVER your design specifies a natural or synthetic rubber product to close dimensions, remember that LINEAR precision molding will save you money. No matter how tough the job, LINEAR specializes in producing molded parts held to the closest tolerances possible. To you, this micrometer accuracy means:

1. A lower rejection rate eliminating hurried repurchases or a work stoppage due to lack of parts.
2. Easier installation insuring an efficient, smooth-rolling assembly line.
3. Improved performance of your production units drawing wider acceptance and more sales for you.

Whether your requirements are for Precision Molded Diaphragms, Boots, Impeller Seals, "O" Rings, or odd shaped parts—see LINEAR for the accuracy which counts!

***plus** Laboratory controlled compounds . . .
Engineering service . . .
And an invitation to consult us during the design stage.*

"PERFECTLY ENGINEERED PACKINGS"

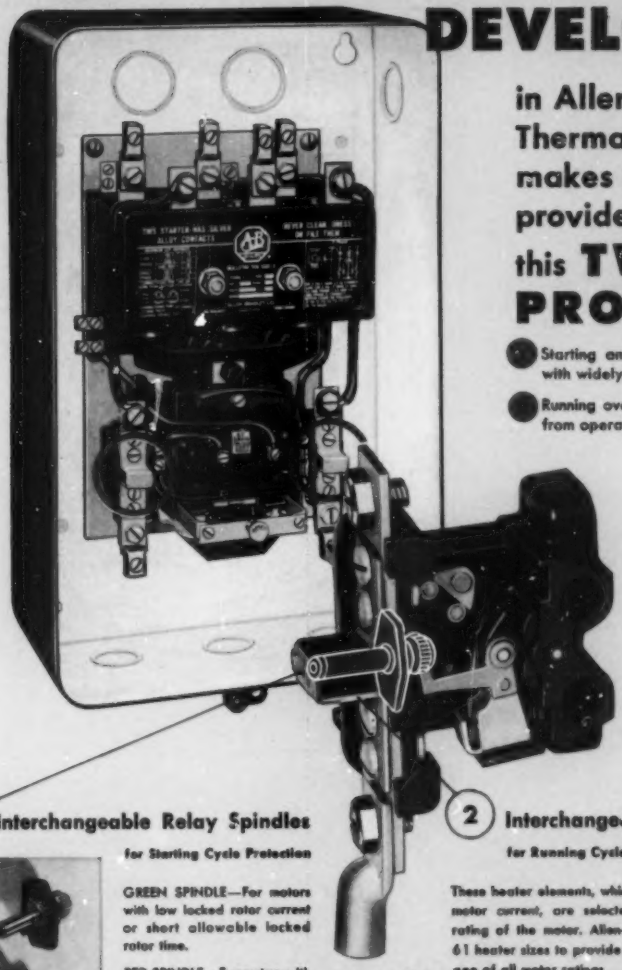
LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILADELPHIA 35, PA.

# A SPECTACULAR DEVELOPMENT

## in Allen-Bradley Thermal Overload Relays makes it possible to provide your motors with this TWO WAY PROTECTION

- Starting and locked rotor protection for motors with widely different characteristics.
- Running overcurrent protection to prevent motor from operating at damaging temperatures.



Now you can match your overload protection for motors under starting and locked rotor conditions as well as under running conditions. Allen-Bradley starters now have interchangeable overload relay spindles to provide various tripping characteristics. The proper spindle gives your motor locked rotor and starting protection. The proper heater element gives running protection. Unnecessary shutdowns will then be eliminated.

### 1 Interchangeable Relay Spindles

**for Starting Cycle Protection**

GREEN SPINDLE—For motors with low locked rotor current or short allowable locked rotor time.

RED SPINDLE—For motors with normal allowable locked rotor time and normal starting time.

TAN SPINDLE—For motors with normal allowable locked rotor time and long starting time. Ideal for flywheel and other high inertia loads.

Bulletin 815 Resisto Therm Overload Relay... the type used on most Allen-Bradley motor starters.

### 2 Interchangeable Heater Elements

**for Running Cycle Protection**

These heater elements, which carry the main motor current, are selected to match the rating of the motor. Allen-Bradley supplies 61 heater sizes to provide adequate coverage of all motor ratings.

These heaters, when used in conjunction with the three types of spindles illustrated at left, provide 183 combinations to match the characteristics of your motors.

That's why Allen-Bradley motor starters provide full motor protection.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

A-B Quality

2-50-MR

(OVER)

# HOW *Interchangeable Spindles and Heater Elements provide*

## on Allen-Bradley Starters

MOST overload relays protect motor windings during the running cycle. But, because motors and motor loads vary so much in character, an overload relay with a single characteristic is unable to provide full motor output and protection under starting and locked rotor conditions.

Now, Allen-Bradley offers *interchangeable* relay spindle assemblies in three types—red, green, or tan—which can be changed in the field from the front of the starter. Each has a different over-current tripping characteristic. The running rating of the relay, however, is determined solely by rating of heater element. Heater element provides full running cycle protection; relay spindle assembly provides full protection during starting cycle and locked rotor conditions.

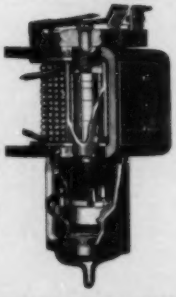
If you will give Allen-Bradley engineers complete information on your starting cycle, normal running current, frequency of starting, and ambient temperatures, they will supply the correct combination of heater unit and relay spindle assembly to fit your motor and load condition.

As a result, it will be possible to keep your motor running at a safe operating temperature during starting, running, and locked rotor conditions—adding years of motor life. Now you can work motors safely to full capacity—eliminating unnecessary, costly shutdowns. Write for full information.

## OTHER ALLEN-BRADLEY OVERLOAD RELAYS

**BULLETIN 810**
**DASHPOT TYPE**
**MAGNETIC OVERLOAD RELAY**

Resets quickly after tripping. Ideal for woodworking and other equipment where motors frequently stall. Trip current and tripping times adjustable. Silicone dashpot fluid practically eliminates changes in tripping time with temperature.



**BULLETIN 820**
**INDUCTO THERM**
**OVERLOAD RELAY**

For accurate overload protection of slip ring and squirrel cage motors having normal allowable locked rotor times and locked rotor currents five or more times full load current. Tripping value easily adjusted over wide range.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

**ALLEN-BRADLEY**

QUALITY

A-B Quality

2-50-MR

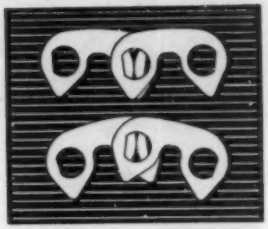
Raymond
SPRINGS
make things move!
Raymond Manufacturing Co.
DIVISION OF ASSOCIATED SPRING CORPORATION
Corry, Pennsylvania
SPRINGS · WIRE FORMS · SMALL STAMPINGS

# SILENT CHAIN DRIVES ARE NOT ALL ALIKE

**Look at the JOINT STRUCTURE and see the difference.**

Alike in general appearance. Alike in interchangeability for operating on various makes of sprockets. But NOT alike in the joint—the heart of a silent chain. Look at the joint of a Ramsey Silent Chain and see immediately why it is different from all other silent chains. The Ramsey joint is designed on the roller bearing principle, resulting in joint action that is practically friction free. A Ramsey chain, with this joint in every link, will operate at high speeds without heating and with no more lubrication than a roller bearing. This means maintenance cut to the bone, smooth operation of the machine being driven and long life to the chain drive. You can't afford to overlook RAMSEY SILENT CHAIN DRIVES. Send for Engineering Catalog No. 650. It's free. It's full of design information and application ideas for silent chains. RAMSEY CHAIN COMPANY, INC., 5051 BROADWAY, ALBANY, N. Y.

"The Chain with the ROLLER BEARING JOINT"



The RAMSEY JOINT STRUCTURE. See how the rolling action of the pins reduces friction to a minimum. Note the open construction that allows oil to penetrate and adhere to the working surfaces. Only a slight amount of oil is required. No oil bath necessary.

## RAMSEY SILENT CHAIN DRIVES

---

*Quantity*
PRODUCTION
*of*
GREY IRON CASTINGS

ONE OF THE NATION'S LARGEST AND MOST MODERN PRODUCTION FOUNDRIES

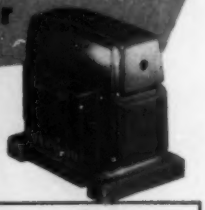
ESTABLISHED 1866

**THE WHELAND COMPANY**
FOUNDRY DIVISION

MAIN OFFICE AND MANUFACTURING PLANTS
CHATTANOOGA 2, TENNESSEE

---

**The ANSWER**
**to controlling air electrically!**



**MODEL NE**
***Electric***
**VALVE**

**10 WATT SOLENOIDS**—Low power requirements. No relays, no transformers required. Operates directly off regular 110 or 220 v. circuits. Solenoids continuously rated.

**FAST, EFFORTLESS CONTROL**—Works by push button, limit switch, or any light contact. Only momentary contact needed. Ideal for remote control . . . interlock or sequence operation . . . building into equipment.

**DISC TYPE**—Pilot controlled; piston operated. Metal-to-metal seat; positively air-tight. Quiet, self-lapping, long lasting. No packing or seals to maintain.

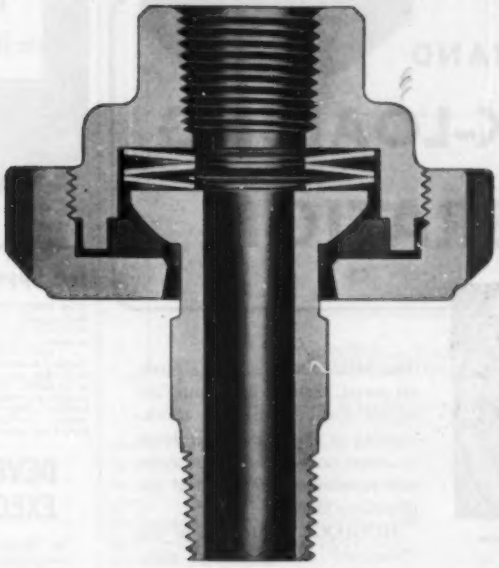
**HANNIFIN ENGINEERED**—Small, rugged, self-contained. Type 1 for control of advance and return cylinder strokes through separate push buttons. Type 2 for single push button control—equivalent to spring return valve action. Sizes ⅜", ½", and ¾". 25 to 150 p.s.i.

*Ask for Bulletin 230*

**HANNIFIN** *Corporation*

1123 So. Kilbourn Avenue • Chicago 24, Illinois
*Nationwide Sales and Service*

# *Improved Barco Rotary Swivel Joints*
# FOR MINIMUM FRICTION



**FRICTION-FREE PERFORMANCE WITH LOWER TURNING TORQUE.** This compact, lightweight, low cost joint is especially efficient at high and low temperatures and pressures. It handles alternating steam and cold water without leakage. It is much more compact for the same capacity and has performed successfully on continuous rotation applications up to 30 RPM. This new, low torque joint will greatly reduce power costs and worker fatigue. It is practically maintenance free.

**WIDE TEMPERATURE AND PRESSURE RANGES.** The new Barco Rotary Swivel Joints withstand these extreme ranges with complete safety, no chance of bursting. Angular motion compensates for misalignment and there is no restricted internal diameter as in flexible hose.

• • •

Install these remarkable joints now. Our engineers will gladly discuss your problems. Sizes ⅜", ½", ¾", 1". When ordering, give complete information about pressures, temperatures, fluids or gases, and any other special conditions.

**BARCO** ***FLEXIBLE JOINTS***

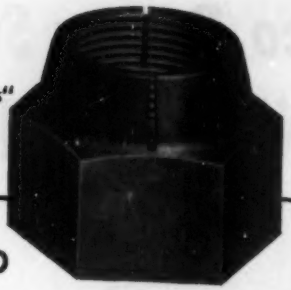
*Not just a swivel joint ... a combination of ball joint and ...ent*

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

"MOVE IN EVERY

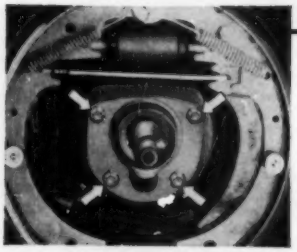
1827 D. Winnemac Avenue, Chicago 40, Illinois • *In Canada:* THE HOLDEN CO., LTD., MONTREAL, CANADA

**NAT SAYS:**
These "Huglocks" are the nuts to . . .



WITHSTAND

# SHOCK-LOADING OR VIBRATION



Huglocks on rear brake backing plate

Huglocks used to fasten differential carrier to rear axle housing

The HUGLOCK is a one-piece, all-metal, self-locking nut designed for use wherever shock-loading or vibration is a problem . . . even under heat, oil or moisture conditions. (See typical applications shown.)

HUGLOCK is just one of the "National" family of lock nuts, designed to fit every fastening need . . . for stress, shear, shock or vibration . . . for heavy or lightweight materials.

Other "National" Lock Nuts include: MARSDEN—for effective locking at minimum cost. DRAKE — for rugged, heavy equipment where severe stress, shock or vibration must be overcome. DYNAMIC — for lightweight, low-clearance locking in shear.

***To help you select*** the right Lock Nut for your assembly, write for this Lock Nut booklet . . giving engineering, design, and weight data.

National
PRODUCTS

THE NATIONAL SCREW & MFG. COMPANY . . . CLEVELAND 4, OHIO

*What makes one man worth $40,000 — another only $4,000? . . . this book tells . . .*

## HOW TO CULTIVATE YOUR TOP EXECUTIVE QUALITIES . . .

## —and win success faster in the upper brackets

TOP EXECUTIVES aren't born. They're made. Self-made mostly. Though they rise along different routes, the steps to their success are similar. They follow a definite course of action . . . and arrive at the top **as planned.** Now, here is a practical, inspiring book which brings you this amazing success formula. It outlines a specific, detailed plan for cultivating the qualities which mark the top-flight business leader today—illuminating **each point with** intimate, on-the-job studies of currently outstanding executives.

## DEVELOPING YOUR EXECUTIVE ABILITY

By **Howard Smith,** Personnel Consultant, Noted Lecturer, and Instructor with Dale Carnegie Institute. 225 **pages** 5½ x 8, **$3.00.**

This book provides a blueprint that shows how you can win executive success. Showing that executive genius is not a quality one is born with, but the result of concentrated effort along the right lines, the book tells how to direct the same efforts and thinking which you already expend daily toward the definite goal of improving your executive ability. Packed with helpful pointers it tells how the up-and-coming executive can make the most of his capabilities, grow in executive stature, and rapidly qualify for the upper bracket responsibilities and rewards.

**Some facts this book gives you:**

- **how to plan advancement**
- **the secret of executive personality**
- **3 best methods for improving personality**
- **11 ways to put over your personality**
- **24 guideposts to productive thinking**
- **11 aids for making decisions**
- **11 steps for handling worries**
- **how to budget time most efficiently**
- **12 tested techniques for giving instructions**
- **how to talk to groups effectively**
- **how to handle responsibility**
- **how to give yourself publicity**

**SEE THIS BOOK TEN DAYS FREE—MAIL COUPON**

McGraw-Hill Book Co., 330 W. 42 St., N.Y.C. 18
Send me Smith's Developing Your Executive Ability for 10 days' examination on approval. In 10 days I will send $3.00, plus few cents for delivery, or return book. (We pay for delivery if you remit with this coupon; same return privilege.)

Name .....
Address .....
City and State .....
Company .....
Position ..... PFE-3-50
Books sent on approval in U. S. and Canada only.

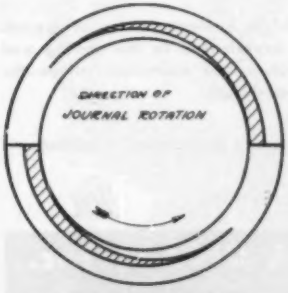
# Flanged Sleeve Bearings

THE addition of a flange on a sleeve bearing often serves as a very useful device to the designer. For instance it is an ideal way of meeting the problem of end thrust. Or it can serve to locate or anchor the bearing; to act as a divider; or to form a recess to hold the lubricant. In some cases, particularly in electric motor bearings, the flange has a beveled edge to insure alignment.

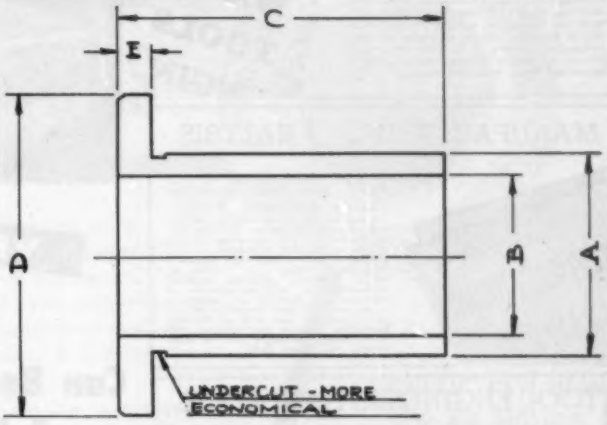
In cast bronze bearings the flange can be located anywhere on the outside diameter and can be made any thickness as required. In sheet metal bearings the location of the flange is limited to the ends and cannot be any thicker than the metal used in the body of the bearing.

In applications where the principal use of a flange is to meet a thrust condition it is well to include oil grooves on the face of the flange. In cast bronze the most popular type is the wedge shape as illustrated herewith. This permits the introduction of oil in order to produce the hydraulic pressure required to separate the flat surfaces. Sheet metal bearings usually employ a design known as "tear drop."

In applications where the operating speed is comparatively slow, it is often wise to use graphite impregnated bearings. The graphite can be included on both the inside diameter and the flange of the bearing. In some cases it is often difficult or impossible to locate the oil intake in the proper place to insure good lubrication while at the same time make it convenient and accessible. The use of flange in applications of this nature provides a reservoir for the lubricant. The oil intake can be placed in the most convenient place on the housing while the corresponding hole in the bearing can be placed where operating conditions demand.




**Recommended type of groove on face of flange.**




**Measurements to specify when ordering Flanged Bearings.**

A. Outside diameter of bearing.
B. Inside diameter of bearing.
C. Length—over-all—of bearing.
D. Outside diameter of flange.
E. Thickness of Flange.

## Powder Metallurgy

When the application permits, the most economical method of producing flanged bearings is by Johnson LEDALOYL. With this method the complete bearing is formed, under pressure, to required size and tolerance. All machine work is eliminated and you gain the advantage of the self-lubricating action. Many sizes of LEDALOYL flanged bearings are standard stock items, ready for immediate delivery. Our new catalogue gives a complete listing of sizes available. Write for your copy.

## How to order Flanged Bearings

When ordering or specifying flanged bearing it is important that *all* dimensions are given. This diagram can be used as a guide. When using flanged half bearings be sure to specify whether they are FULL halves or SAW CUT. Saw Cut bearings can be used where shims are included. Full cut bearings are more expensive but are necessary for precision fits. The use of an undercut under the flange lowers production costs but does not interfere with the efficient operation of the bearing.

## Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

●

*This bearing sheet data is but one of a series. You can get the complete set by writing to—*

Johnson Bronze

**SLEEVE BEARING HEADQUARTERS**
**508 S. MILL ST. • NEW CASTLE, PENNA.**

## MACHINE TOOLS FOR ENGINEERS

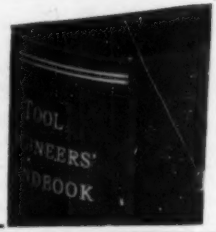
**1.** A new book on manufacturing processes describing all types of machine tools, how they are used, what they can do, and how they affect product design. Gives latest data on grinding techniques, advances in surface finishes and machining processes. Explains machine tool limitations, stressing the production side of machine tools to engineers who will design the products to be made with them but will not operate the tools. **By C. R. Hine, Rensselaer Polyt. Inst. 355 pages, $3.50.**

## MANUFACTURING ANALYSIS

**2.** Up-to-date in every respect, this book describes various processes, machinery and tooling for the efficient production of consumer goods. Includes case studies to aid you in mastering tool and process engineering techniques . . . presents a study of inspection procedure and quality control . . . covers assembly methods, materials handling equipment, etc. Analyzes sequence of operation and selecting the equipment to be used. Studies of production and tool estimating, and costs of different machining methods are included. **By R. F. Kipers, Rochester Inst. of Technology. 432 pages, $5.00.**

## TOOL ENGINEERS HANDBOOK

**3.** An outstanding reference on planning, control, design, tooling and other operations in the mechanical manufacturing industries. Covers product design and cost estimating, the economical selection of machines, processes and tools, the analysis and improvement of setups and operations. Tables of feeds, speeds and cuts are modernized to bring you in line with latest cutting-tool materials and cutting practices. **American Society of Tool Engineers: Frank W. Wilson, Editor-in-Chief. Over 2,000 pages, $15.00.**




## PROCESS ENGINEERING

**4.** How to set up money-saving manufacturing methods and eliminate guesswork in cost-estimating. The book shows how to establish the proper sequence of operations and exact labor cost directly from the blueprint . . . how to determine the quantity and cost of materials to be used . . . how to plan efficient tool, dies, jigs, and fixtures for economical production. Explains how to assign established time-values to each movement. **By W. Schutt, Industrial Designer. 300 pages, $4.00.**

McGRAW-HILL

**SEE THESE BOOKS 10 DAYS FREE**

**McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18**

Send me book(s) corresponding to numbers encircled below for 10 days' examination on approval. In 10 days I will remit for book(s) I keep, plus few cents for delivery, and return unwanted book(s) postpaid. (We pay for delivery if you remit with this coupon; same return privilege.)

1 2 3 4

Name .....

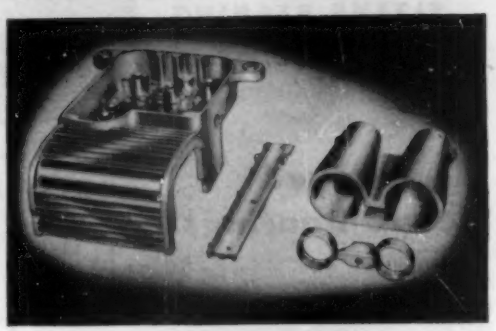
Address .....

City ..... Zone..... State.....

Company .....

Position ..... PE-3-50

**This offer applies to U. S. only.**



**VERSATILE PRODUCTION**

# Can Be Attained By Using ALUMINUM and MAGNESIUM DIE CASTINGS

**Illustrating the versatility permitted to manufacturers who select strong and light weight aluminum or magnesium die castings for their products are the above complex precision parts for the optical field—die cast by LITEMETAL. Plus the great saving of man hours usually required for machining, these die castings of light weight metals offer great strength and dimensional stability, and give adequate rigidity through scientific die casting design with ribbed-in sections.**

**Die Castings of magnesium or aluminum may offer you solutions to many of your cost and production problems.**

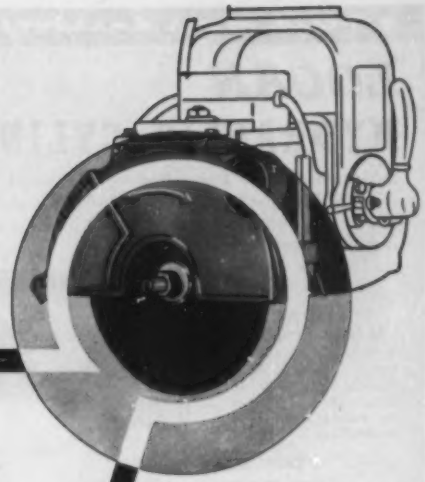
**LITEMETAL DICAST, INC. is an organization of specialists—men thoroughly experienced in the casting and machining of magnesium and aluminum alloys—the new metals of structural design.**

**Write today for literature on Litemetal Dicasting.**

**Quick action on inquiries.**

**LITEMETAL DICAST Inc.**
A DIVISION OF HAYES INDUSTRIES
1921 WILDWOOD AVE. · JACKSON, MICHIGAN
PLANT AND EXECUTIVE OFFICES

# Hoover®
# ELECTRIC MOTORS
## do your reputation a good turn



Drills—lathes—radial saws—whatever machine tools you make—your prestige depends on their instant operation when the switch is turned on. They must start quickly and run smoothly even under conditions of hard, continuous use. Which is why so many manufacturers equip their products with Hoover Electric Motors. (The famous K-C Motors with a new name.)

There's a wide variety of capacitor-start and polyphase Hoover Motors engineered especially to give smooth, quiet, trouble-free service to machine tools, compressors, pumps and other hard-to-start, continuous-duty equipment.

Write today for complete information. You'll find there's a Hoover Motor to fit *YOUR* requirements . . . to do *YOUR* reputation a good turn.

### "HOOVER" NEW NAME FOR K-C MOTORS

Motors made by the Kingston-Conley Division of The Hoover Company have long been known as "K-C Motors." In the future, these same fine motors will bear the name of the parent company—maker of the world-famous Hoover Cleaner. Standards of design, construction and performance continue as high as ever—outstanding in the industry.

Typical single-phase capacitor-start Hoover Motor. 1 HP, 1725 RPM. Rigid-mount, ball-bearing, dripproof construction. Conforms to NEMA mounting standards. *Features external, removable switch housing, which prevents dust or dirt from lodging between contact points and causing starting trouble.*

Polyphase Hoover Motors available in ratings from ¼ to 2 HP.

Split-phase Hoover Motors, ¼ to ½ HP, available for easy-to-start, quick-to-accelerate applications such as fans, blowers, light machine tools.

**THE HOOVER COMPANY**
North Canton, Ohio
**Kingston-Conley Division**
86 Brook Avenue
North Plainfield, New Jersey

* Fluid Power Improves Production

# "LOGAN" Rotocast® HYDRAULIC CYLINDERS

Built into this new Logan line are operational advancements that will help you improve product efficiency and reduce costs. Here's fast-acting, positive controlled power for all types of industrial applications.

**7 STANDARD MOUNTINGS**

• Rabbited • Foot • Center Line • Clevis • Trunnion • Flange at blind end • Flange at rod end—or any desired combination.

***ENGINEERING COUNSEL**

Write for recommendations on the proper cylinders for your applications and most effective method of installation.

Standard Rotocast Hydraulic Cylinders in sizes from 2" to 8" bore; any length stroke up to 8 feet. Other bores and lengths are special. Four piston rod end types. Operating pressures to 1500 p.s.i.

Logan Rotocast Cylinders properly conditioned can also be used for water service.

**CHECK THESE ROTOCAST FEATURES AGAINST YOUR PRESENT SETUP**

- Smooth, uniform power flow assured by clean, accurate cylinder bores—honed to a mirror finish.
- Close-grained centrifugal-cast barrel assures dimensional accuracy throughout life of cylinder.
- Maximum power assured. Automotive-type piston rings and smooth, true bore minimize friction and leakage past the piston.
- Permanent, leakproof seal between barrel and end covers provided by "O" rings of pliable, synthetic material. No gaskets.
- Standard models with or without cushioning. Vent ports may be located at top, bottom or either side. Piston rods available in standard, 2:1 differential, and double end types.

Logan SAVES TIME • EFFORT • MOTION

Air and Hydraulic Equipment

LOGANSPORT MACHINE CO., INC. 812 Center Ave. Logansport, Ind.

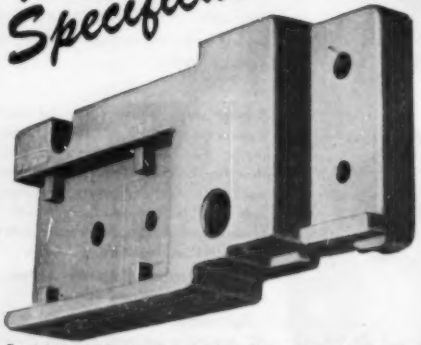
**FREE CATALOGS**

Send for catalog on Logan ROTOCAST Hydraulic Cylinders. Also ask for data on Logan Hydraulic Valves and Power Units.

FLUID POWER SPECIALISTS SINCE 1916

# PORCELAIN INSULATORS

## To your Specifications U



Precision molding to your specifications is our first consideration in manufacturing Universal Porcelain Insulators. And, added to that, you'll find uniform density of body, close tolerance dimensions, high dielectric strength and resistance to temperature extremes, moisture, fumes, smoke and acids. Universal's engineering experience may be helpful to you in the development of insulators to your exact requirements.

THE UNIVERSAL CLAY PRODUCTS CO.

1545 EAST FIRST STREET SANDUSKY, OHIO

TRADE MARK

## Engraving

Here is the most versatile machine...So simple to operate by unskilled labor.

**PROFILING** VERTICAL **MILLING**

**NEW HERMES Engravo**

This heavy duty bench type model covers a larger engraving area than any other machine of its kind.

NEW HERMES, Inc.

Dept. 30 13-19 UNIVERSITY PL. • NEW YORK 3

World's Largest Manufacturer of Portable Engraving Machines

# AL Stainless Steel Castings meet any need for Cleanliness

**Data on the Uses of ALLEGHENY METAL in Various Industries**

Available *now*—informative booklets on Allegheny Metal in the Chemical, Petroleum Refining, Brewing, Meat Packing, and Dairy Industries—others in preparation. Write for this valuable data on the field in which you are interested.

**ADDRESS DEPT. PE-3**

Note the clean, sound, fine-grained appearance of the Allegheny Metal sanitary fittings shown above, in the "as-cast" condition. They're typical of the wide variety of stainless steel castings we produce for the chemical processing, food, dairy, beverage, oil, paper and textile industries, etc.—wherever the purity and quality of products must be maintained, and where ease of sanitation and assurance of long, trouble-free service are prime considerations.

Allegheny Metal castings are produced by methods specially developed to protect uniform quality and guard against defects. You'll find them superior both from the standpoint of machinability and soundness. ● Let us quote on your stainless casting requirements—any shape and any size, from a few ounces to 5000 pounds.

**ALLEGHENY LUDLUM STEEL CORPORATION**
**Pittsburgh, Pa.**

*Nation's Leading Producer of Stainless Steels in All Forms*

W&D 2451

ALLEGHENY METAL is stocked by all Joseph T. Ryerson & Son, Inc. warehouses

# MAGNAFLUX INSPECTION

Our Magnaflux Inspection has played an important part in our having received the A.A.F. Approved Quality Control Rating A.A.F. Certified Magnaflux Operators and Certified Inspectors carefully check all Curtis Joints intended for aircraft applications.

## *Guards* CURTIS PRODUCTS

Curtis Universal Joints *still* have to pass the rigid requirements of Magnaflux inspection and other tests originally set by the Air Force and Navy for torque, tensile strength, fatigue of materials and radial play. Curtis has complete inspection, testing and laboratory equipment that is constantly used to check quality.

**WHAT DOES THIS MEAN TO YOU? ? ?**

It means you are getting flaw free materials specially heat treated, combined with Curtis workmanship, to give the strongest and most durable joint you can buy.

It means you will have less "down time" in your plant due to universal joint failure.

It means your operating and maintenance costs will be less, even though original cost may be slightly higher.

It means you will have smoother, quieter, more efficient operation of offset drives or controls.

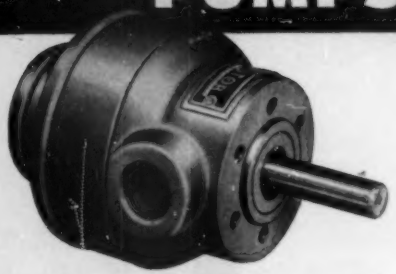
Therefore, when you need universal joints for any industrial application, you can be sure of the highest quality by buying Curtis Universal Joints.

Available from stock in 14 standard sizes from ⅜" to 4" O.D. Special joints made to specification.

**BUY DIRECT FROM CURTIS!**
***Sole Makers of Curtis Joints***

**CURTIS UNIVERSAL JOINT CO. INC.** Write Dept. U-3 SPRINGFIELD, MASS.

# GEROTOR hydraulic PUMPS



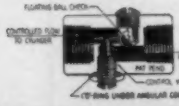
## for high volumetric and mechanical efficiency

Exclusive GEROTOR elements revolve in the same direction at low relative speed, resulting in less wear, longer life. Continuous fluid-tight tooth engagement means less slippage, more uniform flow. Pressures up to 1000 p.s.i., continuous duty; in some sizes, up to 1200 p.s.i. continuous, 1500 intermittent. Plain, base or flange mounting. Write for catalog.

**GEROTOR** hydraulic pumps & motors
GEROTOR MAY CORPORATION, Baltimore 3, Md.

# FLOW CONTROL VALVE for Cylinder Speed ADJUSTMENTS over a WIDE RANGE IN AIR OR HYDRAULIC USE

The Pneu-Trol Flow Control Valve combines an efficient Stainless Steel FLOATING BALL CHECK which opens and closes at the slightest change in flow direction, with a Vernier Type VARIABLE NEEDLE ORIFICE adjustment in a compact control which has widened air and hydraulic cylinder application by providing precise control of cylinder action. Modifications of the Pneu-Trol Valve are available as Plain Check, check with Fixed Orifice (orifice drilled by customer in the Standard Check Valve), Need'e Valve and Velocity Limiting Check, as illustrated at left. All Pneu-Trol Valves are made from bar stock in brass (up to 1000 psi) or steel (5000 psi) or other body metals to your specifications. All internal parts are Stainless. All valves available in 5 sizes—⅛", ¼", ⅜", ½", and ¾". Attractive prices — immediate delivery. Write for illustrated circular and price list.



WRITE

**Pneu-Trol Devices, Inc.**
3122 N. California Ave. Chicago 18, Ill.

# HOW TO PREVENT *headaches* IN YOUR BRAIN CHILD

A new product involving the use of springs or formed wires can often cause a lot of headaches. But hundreds of manufacturers have saved themselves time, trouble and expense by taking our engineers into their confidence before the final design stage.

Our engineers analyze the proper relationship between the factors involved in a particular spring design . . . load, deflection, size, shape, finish, etc. Then after they have designed a spring that will stand up under the service requirements demanded, our mill men take over. These skilled toolmakers (many of whom have been with us for over 25 years) build into the spring the craftsmanship that, for over 125 years, has been a Wickwire tradition.

Small wonder then, that our list of repeat customers is constantly growing. They have seen their brain children develop into sturdy products that have bounced their way into profitable sales fields. Why not make an appointment to see us about *your* spring problem? There is no obligation and it may erase a lot of worries on your part.

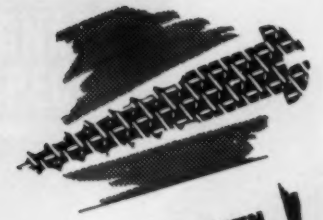
*Send for our free book, "Springs and Formed Wires." It's full of valuable data about spring selection and performance.*

**CF&I WICKWIRE SPENCER SPRINGS**

A PRODUCT OF THE WICKWIRE SPENCER STEEL DIVISION • THE COLORADO FUEL AND IRON CORPORATION

SPRING SALES OFFICE & PLANT—2 New Bond St., Worcester 6, Mass. • EXECUTIVE OFFICE—500 Fifth Ave., N. Y. 18, N. Y.
SALES OFFICES—Boston • Buffalo • Chicago • Denver • Detroit • New York • Philadelphia
PACIFIC COAST—The California Wire Cloth Corp., Oakland 6, Cal.

Other Quality Wickwire Spencer Products Include: Wire, Wire Rope, Metal Conveyor Belts, Chain Link Fence, Industrial Wire Cloth Poultry Netting, Hardware Cloth, Insect Wire Screening, Welded Wire Fabric for concrete reinforcement.



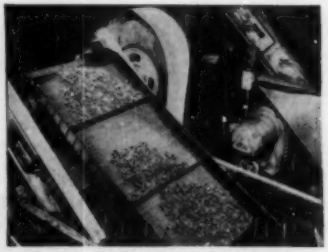
## Cambridge WOVEN WIRE BELTS

## Tailored to your Production Needs

Your Cambridge woven wire conveyor belt is engineered from the raw materials to the finished belt to give you maximum efficiency with a minimum of attention and maintenance.

Cambridge designs withstand heavy loads, high temperatures, cold, corrosive compounds or wet processes. They may be fabricated of any metal or alloy in any mesh and weave. Where necessary, Cambridge belts can be fitted with various types of selvages, cleats and drives.

Call your Cambridge Field Engineer whenever you have a problem concerning movement of materials during processing.



A Cambridge Rod-Reinforced Belt with Plate Selvages and Fabric Cleats provides cost-cutting continuous quenching of screws, nuts and bolts. This belt design offers the highest tensile strength, low thermal capacity and successful operations in temperatures as high as 2100° F.

**VALUABLE BOOK, FREE! A complete, basic reference on conveyor belts, designs, systems and metallurgy. Write for your copy or call your nearest Cambridge office.**

**Cambridge Wire Cloth Co.**

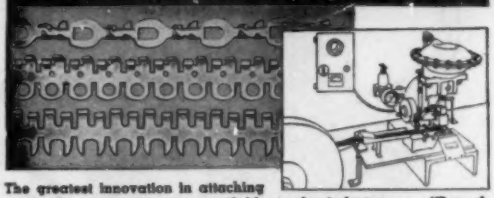
Department P
Cambridge 3, Md.

Wire cloth in rolls. Also specialized wire fabrications

**OFFICES IN PRINCIPAL INDUSTRIAL CITIES**

*See "Belting, Mechanical" in your Classified Telephone Directory.*

## Now Terminals Can Be ATTACHED & SOLDERED in ONE Automatic Operation!



**The greatest innovation in attaching terminals to wires is now available to the industry . . . "Pre-soldered" TANDEM TERMINALS! Made in various sizes and types, these remarkable, production-proved terminals (supplied on reels) can be applied at rates up to 1200 per hour by a new Terminal Attaching Machine that cuts off, clinches and solders terminals in one instantaneous operation. Handling of loose terminals, solder and flux are eliminated to reduce costs and boost production on long runs. Standard types available. Send for detailed information, enclose sample of wire and terminal now used. Address Dept. B.**

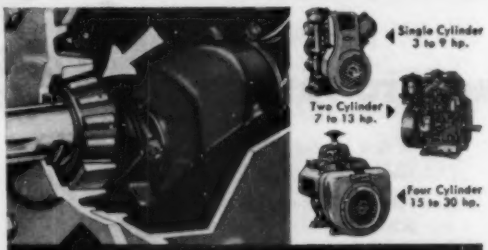
*For ordinary runs in moderate quantity we continue to produce*

**SEPARATE TERMINALS for ELECTRIC WIRES**

**We also make SMALL METAL STAMPINGS Exact to Customer's Prints. Modern Plant and Equipment. Moderate Die Charges. Precision Work. Prompt Service.**

## PATTON-MacGUYER COMPANY

17 Virginia Avenue, Providence, R. I.




## Why WISCONSIN HEAVY-DUTY Air-Cooled ENGINES Run on Timken Tapered Roller Bearings

**1. Tapered Roller Bearings at BOTH ends of the crankshaft take up *End Thrusts* and *Radial Loads* (impossible with other types of bearings). You can mount your drive directly on the extended crankshaft of any Wisconsin Engine without the need for special thrust bearings.**

**2. Tapered Roller Bearings *resist wear* to a greater extent than other types not only because of their file-hard alloy steel surfaces, but also because these bearings are inherently SELF-CLEANING.**

**3. Tapered Roller Bearings permit flexing of the crankshaft to a much greater degree than the longer, rigid plain bearings, without danger of developing "bell-mouthed" wobble. We have yet to hear of a single case of Wisconsin Engine bearing failure.**

**The use of Tapered Roller Bearings in ALL Wisconsin Engines from the smallest to the largest . . . 3 to 30 hp., single cylinder, 2-cylinder and 4-cylinder . . . is typical of the engineering diligence devoted to providing the user with "Most H.P. Hours of on-the-job service".**

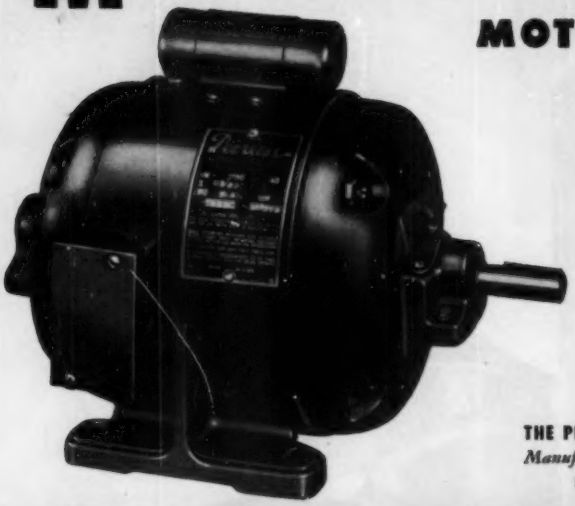
**WISCONSIN MOTOR CORPORATION**

World's Largest Builders of Heavy Duty Air-Cooled Engines

MILWAUKEE 46 WISCONSIN

Basic principles of lubrication govern the performance of sleeve bearings. Proper application of these principles and the innate quality of Bunting Bronze Bearings give assurance of successful operation in service. The wide experience of our engineers is at your disposal. THE BUNTING BRASS & BRONZE COMPANY, Toledo 9, Ohio. Branches in Principal Cities.
BRONZE BEARINGS
PRECISION BRONZE BARS
BUSHINGS
64
Bunting

# MAKE PEERLESS ELECTRIC *your* MOTOR DEPARTMENT



● When you bring your motor problems to Peerless Electric, you add a motor department to your plant facilities. Peerless is small enough to give individual engineering attention to your motor requirements—large enough to manufacture the motors you need in any quantity.

We can give you the same quick action on special motors that you could get in your own plant if you had a motor department —action that will give you promptly the information or samples you may need.

**THE PEERLESS ELECTRIC COMPANY • WARREN, OHIO**

*Manufacturers of Quality Motors for more than 55 years.*

**Single Phase • Polyphase • Direct Current Motors**

**ALL *Peerless* Motors ARE "PEERLESS REGISTERED"**

***the right answer***

**. . . to every gauge need IN THIS NEW CATALOG**

The right answer—the Marsh answer — to every pressure gauge need is described by this new Marsh catalog which covers hundreds of variations of styles, types, mountings, ranges, functions. Remember that Marsh gauges, from the "Standard" series line to the heavy-duty "Mastergauge" series have proved across the years to be the most economical you can buy for a given set of conditions. Let us prove this in terms of gauges for your product.

**MARSH INSTRUMENT CO.**

*Sales affiliate of*
Jas. P. Marsh Corp., Dept. 39, Skokie, Ill

How You Can Lick
Your Clutch Problem
Whether your's is a size, type or capacity clutch problem, you can save time and effort in solving it by utilizing the quarter century of clutch designing and building experience available in the ROCKFORD engineering department. This service not only offers you a vast fund of power transmission and control know-how, but enables you to examine thousands of successful ROCKFORD CLUTCH applications in hundreds of industries. A letter or phone call will bring prompt assistance.
ROCKFORD
Power Take-off
CLUTCHES
BW
ROCKFORD CLUTCH DIVISION
BORG-WARNER
209 Catherine Street, Rockford, Illinois

The Model 53 GARLOCK KLOZURE Oil Seal consists of: a precision built metal case; a metal adapter; a metal spring with fingers or lugs which are extremely sensitive; and a flexible, resilient sealing element specially compounded by GARLOCK to resist oil and heat.

The light, uniform, positive spring loading combined with the tough, resilient sealing element, result in "live action" sensitivity and long life of these superior KLOZURE seals. Recommended for high or low shaft speeds and for shafts having considerable "whip" or lateral movement.

Model 53 KLOZURE is produced in a range of sizes for 3" to 10" shafts. Model 63 KLOZURES, employing the same engineering principles but differing in details of design, are made in a range of sizes from ¼" to and including 3" shafts.

For those applications for which none of our regular KLOZURE models is suitable we design and manufacture oil seals of many special types: small seals for needle bearings, seals for self-aligning or spherical bearings, rugged seals with garter springs for steel mill roll necks, etc.

*Write for KLOZURE Catalog!*

**THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK**
**In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.**

Garlock KLOZURE®

® REG. U. S. PAT. OFF.

# Phoenixspun PROCESSING

. . . provides extensive facilities, plus engineering skill, to solve any type of fabricating problem involving modern industrial metals. Spinning of large diameter, deep-drawn or formed forms is a PHOENIXSPUN specialty. Your specifications or prints will bring our prompt estimates.

"Jobs Well Done Are PHOENIXSPUN"

PHOENIX PRODUCTS Co.
*Metal Spinning Div.*
4723 N. 27th Street
Milwaukee 16, Wis

## How to organize, operate and control a product-design engineering department

Here is a book that will show you tested methods to facilitate production and reduce costs in your engineering department. Designed to minimize paperwork without sacrificing control, this book outlines the basic functions necessary to all successful engineering departments, large and small. These fundamentals are discussed in full to clearly point the way to smoother operation, higher production and greater economy in your organization.

## ENGINEERING ORGANIZATION AND METHODS

by JAMES E. THOMPSON

*Consulting Industrial Engineer; Formerly Chief Engineer Booth Manufacturing Corporation; Administrative Engineer, The Ryan Aeronautical Company*

**337 Pages, 6 x 9, $4.00**

McGraw-Hill Industrial Organization and Management Series

This practical guide analyzes each step of procedure used by successful engineering departments to handle prime functions and establish basic control. In its fifteen chapters you are led through a complete study of your problems relative to organization, personnel, cost control, drawings, part numbering, cataloging, print control and many other important subjects. It explains methods found superior in delegating authority, apportioning duties and avoiding overlapping between sections. Over 150 charts and diagrams assist you in clearly understanding the methods described. The information in this book applied to your organization will result in maximum efficiency and cost reduction.

**15 Helpful Chapters:**

1. Organization
2. Operation
3. Personnel
4. Cost Control
5. Planning
6. Standards
7. Drawing and Report Numbering
8. Drawing Forms and Title Blocks
9. Drawing Release
10. Drawing Print Control
11. Advance Engineering Information
12. Drawing Changes
13. Technical Services
14. General Services
15. Fundamentals of Engineering Management

**10 Days FREE Examination—Mail Coupon**

McGraw-Hill Book Co., 330 W. 42 St., NYC 18

Send me Thompson's ENGINEERING ORGANIZATION AND METHODS for 10 days' examination on approval. In 10 days I will send $4.00, plus a few cents postage, or return book postpaid. (Postage paid on cash orders.)

Name .....

Address .....

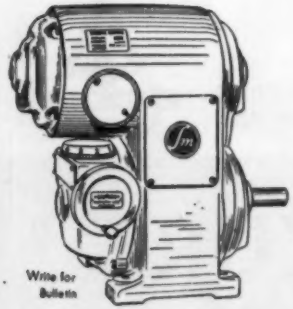
City and State .....

Company .....

Position .....PPE-3-50

Books sent on approval in U. S. and Canada only.

Uncork Bottle-necks



Write for Bulletin

Open up production bottlenecks with Sterling Speed-Trol Electric Power Drives.

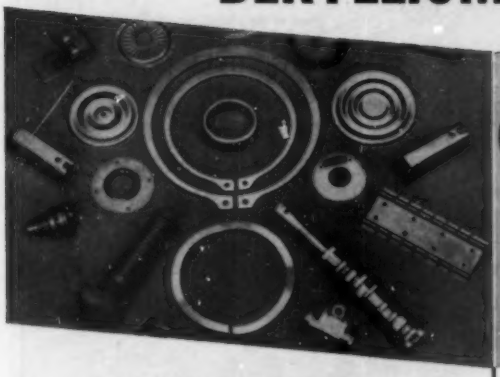
STERLING ELECTRIC MOTORS

Plants: New York • Los Angeles • Hamilton, Canada
Offices in Principal Cities

SPEED-TROL (Variable Speed) • SLO-SPEED (Geared) • KLOSED (Normal Speed)

## Have You Considered Every Design Advantage of

# BERYLLIUM-COPPER?



### WROUGHT ALLOYS

Strip, Rod, Bar, Wire.

**BERYLCO 25** ... The standard 2% alloy offers good cold-forming properties in the unhardened condition with the highest strength and hardness of any copper alloy when heat-treated. Excellent conductivity and resistance to fatigue, corrosion and wear make this non-magnetic material ideal for springs, diaphragms, bellows, electrical contacts, electronic equipment, aircraft engine parts, cams and similar components.

**BERYLCO 165** ... A high-strength alloy — available in strip form only — with price and mechanical properties slightly lower than BERYLCO 25. In addition, mill hardened BERYLCO 165 presents cost-saving opportunities by eliminating heat-treatment after fabrication and attains properties appreciably higher than bronze.

**BERYLCO 10** ... A high-conductivity alloy used in those current-carrying springs, switch parts and similar components where electrical or thermal conductivity is of primary importance. Since BERYLCO 10 can be readily formed and machined when hardened, it is generally supplied in this condition, requiring no heat-treatment by the fabricator.

**BERYLCO 50** ... A special resistance welding material (RWMA Class 3) for spot, seam, flash and projection welding dies and electrodes.

### CASTING ALLOYS

Supplied as Pigs or Sand-cast Parts.

**BERYLCO 20C** ... In sand, investment and plaster-mold casting methods, this 2% alloy offers special advantages through good fluidity, low pouring temperatures and high final properties after hardening. Applications include bushings, cams, propellers, pump parts, bearings, gears, safety tools, and valve parts.

**BERYLCO 275C** ... A special-purpose foundry material for plastics molds and other applications requiring maximum strength, hardness and wear resistance.

**BERYLCO 10C** ... A high-conductivity material for switches, circuit breakers, switchgear, welding jaws, resistance welding dies, electrode holders and similar current-carrying members where strength, conductivity and resistance to wear and moderately elevated temperatures are important.

● For more specific information regarding available properties, tempers, mill sizes, etc., write for:

1. BULLETIN 12 — "How to Order Beryllium Copper Strip"
2. BULLETIN 13 — "How to Order Beryllium Copper Rod, Bar and Wire"
3. "Designing with Beryllium-Copper Casting Alloys"

For our recommendations, write giving full details including drawings or samples.

BERYLCO BERYLLIUM BERYLCO

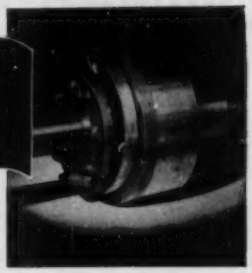
## THE BERYLLIUM CORPORATION

**DEPT. 7, READING 2, PENNSYLVANIA**

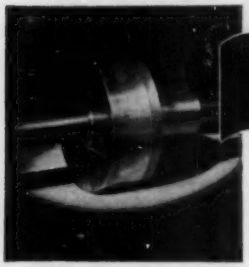
# HILLIARD *Clutches*

**FOR POWER CONTROL DESIGNS**

**HILLIARD**
SINGLE
REVOLUTION
CLUTCH



Unequalled for accurate control of intermittent machine operations — cutting, punching, and packaging. Gives closer tolerances to cut-off, stamping, shearing, and similar machines. Completely automatic; manual, mechanical, or electrical control.



**HILLIARD**
OVER-RUNNING
CLUTCH

Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unexcelled for automatic two-speed drives, dual drives, stand-by drives, and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.

**HILLIARD**
SLIP
CLUTCH

A reliable series of spring-loaded slip clutches and couplings. Rugged construction with ample friction surface for heavy-duty use. Outstanding for preventing overloads and shocks; for starting heavy loads; as tension drag brakes; for reeling and winding operations; and many other uses.

*Hilliard's Engineering Department is ready to assist you in designing installations and in selecting the correct clutch or coupling.*
*Write today — 3 Hilliard Clutch Bulletins with design information. Free on request.*

*Clutch Makers for over 40 years*

*The* **HILLIARD** *Corporation*

WHAT'S NEW IN
AUBURN Plastics

Some of the plastic parts molded by Auburn for Welch-Allyn, Inc., specialists in a wide range of electrically illuminated diagnostic instruments.

# Small parts with a big story for you

These small parts are molded from nylon and phenolic; not shown are other parts using acetate, acrylics, and polyethylene—each recommended for its specific function.

**Auburn molds any plastic material.**

These parts are molded by different methods —each the best for the material and purpose.

**Auburn molds by any modern method.**

These parts have all been engineered from the very start—for economy in mold costs.

**Auburn offers complete engineering.**

What does it mean to *you?* You can rely on Auburn's recommendation for any application of molded plastics, knowing that it is unbiased . . . not colored by limitations of facilities.

The "know-how" we have gained through 74 years is at your service. Write Auburn Button Works, Inc., 350 McMaster St., Auburn, N.Y.

**COMPRESSION, TRANSFER, AND INJECTION MOLDING, AUTOMATIC ROTARY MOLDING FOR MASS PRODUCTION, EXTRUDED ELASTOMERICS, REINFORCED PLASTICS (Fiberglas), MOLD ENGINEERING AND COMPLETE MOLD SHOP**

Auburn Button Works, Inc.
MOLDERS SINCE 1876 • AUBURN, NEW YORK

# Sound to the core . . . to guard your reputation

**Emerson-Electric's unique *Twin-gineering* SERVICE solves your power problems**

Experienced Emerson-Electric Engineers are eager to collaborate with your own staff in designing and providing the proper motor application to your new or improved appliance or equipment. Such collaboration—TWIN-GINEERING we call it—can save you costly engineering "back-tracking," and may suggest short cuts or improvements of great competitive benefit to your product. Write us today . . . there is no charge for this service.

Do your products enjoy the ready acceptance they deserve?

The products you are producing today will determine your reputation in future years. Satisfactory service over a period of time is the decisive test. And so it is with Emerson-Electric Motors . . . sixty years of motor-building know-how have earned for Emerson-Electric the enviable reputation of consistently producing motors with sound engineering and design principles, sound construction—motors that are literally "sound to the core".

Scores of America's most reputable manufacturers recognize that their products are known by the service they perform. For this reason their products are powered by Emerson-Electric Motors . . . thus assured of years of dependable service. Your inquiry is invited as to how Emerson-Electric can guard the reputation of your product with its complete line of motors, 1/20 to 5 h.p.

**THE EMERSON ELECTRIC MFG. CO.**
ST. LOUIS 21, MO.

**EMERSON ELECTRIC**
MOTORS • FANS — APPLIANCES

## WELCO MOTOR Rolls 55 ton Billets

Starting from scratch Welco is prepared to design and build motors to your specification. Please write us your requirements.

**THE B. A. WESCHE ELECTRIC CO.**
1620-1628 VINE ST., CINCINNATI 10, OHIO

Once again Welco Special Torque Motors demonstrate that they begin where standard motors quit. 90 of these power laden monsters in a bank drive the steel mill rolls that handle 55 ton billets. Built for Hydropress, Inc., they are the first of their kind made in the U. S. A. They are totally enclosed, fin cooled, A.C. three phase, 50 cycle and operate at 150 R.P.M.

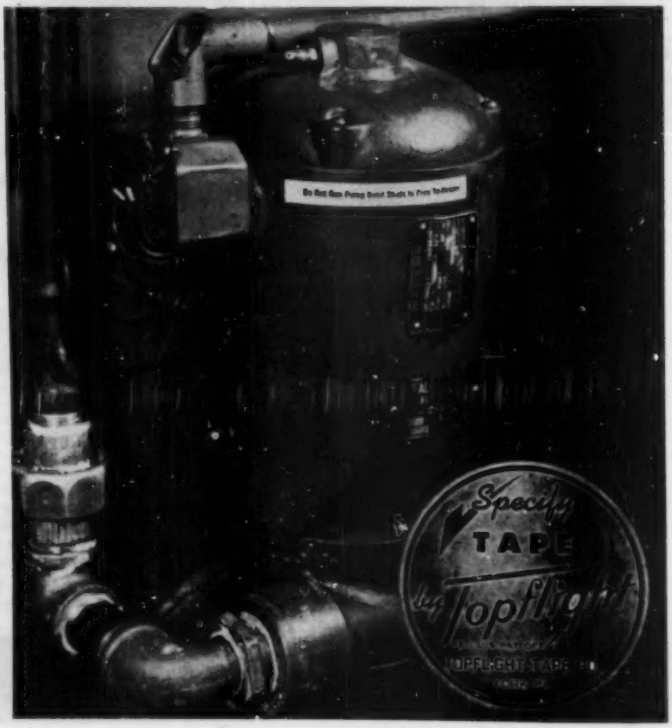
## EMPHASIS PLACED ON OPERATION CARE

### *Warning - instructions, necessary information*

Baker Brothers, Inc. of Toledo, Ohio, produce machine tools requiring a flow of cutting or cooling liquid at the point of drilling or boring. Shown here, is one of the ways they use Topflight Tape. The instruction sticker, "Do Not Run Pump Until Shaft is Free to Rotate" is placed on motor pumps supplying cutting or coolant liquids. When intricate machine tools are delivered and set up, operation instructions are at operator's eye level.

### *Instruct operator*

Topflight printed, pressure-sensitive, cellophane tape is applied in an instant. It will stick to any clean, dry surface at once. Finger pressure is all that is necessary to make it stick. That is why so many firms are turning to Topflight for important warning or instruction stickers. Expensive machine tools must have special care and handling.

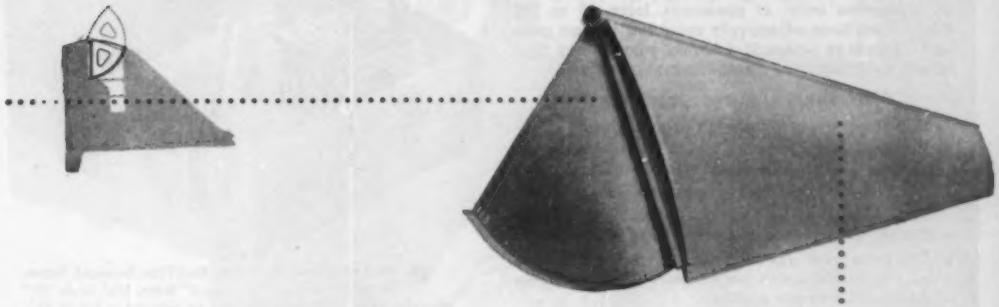



**TOPFLIGHT TAPE COMPANY**
ERWIN HUBER, *President*
YORK PENNA.

ONE OF A SERIES DEMONSTRATING APPLIED LUKENOMICS

# LIFE-TIME GATE GUARANTEE...or how to make

## submerged steel structures last longer, work better, cost less



To provide 4 feet of adjustable control at the top of a 12-foot concrete spillway section, the Huron-Clinton Metropolitan Authority specified a 90-foot drum gate. The final design called for fabrication of three 30-foot all-welded water-tight sections using nickel-clad parts where difficult to paint or when subjected to corrosion or wear. The structure provided maximum stiffness, minimum weight, ease of operation, excellent appearance and an assurance of long trouble-free life.

Benefits like these come from looking beyond mere structural design toward considered materials buying, accurate evaluation of fabrication and erection costs, appearance requirements and a host of similar factors. Such an approach to the *total* problem posed in engineering structures or equipment we term Lukenomics. Lukenomics brings to bear not only Lukens own products, services and knowledge of materials but marshals, as well, industry's skilled consultants, structural shops and equipment manufacturers.

To obtain the advantages of structures or equipment designed or fabricated in accordance with the Lukenomics principle, write our Manager of Marketing Service, Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

*This drum-type gate structure was fabricated by B. C. Mahon Company, of Lukens Nickel-Clad Steel and erected at Kent Lake Dam on the Huron River, a recreational area under development by the Huron-Clinton Metropolitan Authority of Michigan. Ayres, Lewis, Norris & May, consulting engineers.*

LUKENS

LUKENS STEEL COMPANY

**BETTER PRODUCTS FOR BETTER EQUIPMENT**

A-650

# A Small Valve for BIG JOBS
## ...NOPAK 4-Way Model SL RING-TYPE Solenoid VALVE

**Does the work of bulkier, heavier and costlier solenoid valves of same capacity. Designed for air operation only, at pressures from 40 to 250 P.S.I. Functions effectively mounted in any position. Employs solenoid-actuated pilot rather than direct solenoid pull on sealing mechanism.**

### Has the Features you Want!

1. Light 3-piece valve body of drawn aluminum.
2. Chrome-plated Operating Shaft floats in Neoprene O-Rings — requires minimum lubrication.
3. Standard Solenoid Unit — easily replaced, readily available.
4. Current Economy — 0.96 amperes at 220 volts.
5. This valve gives you long-run, high speed operation . . . up to 500 cycles per minute . . . or continuous energization in one position.
6. Sub-Plate mounting furnished at extra cost, if desired.

**NOPAK Model SL, 4-Way Ring-Type Solenoid Valve. Weight 5¾ lbs., 5⅞" long, 3" wide, 5½" high. ½" pipe size only. Cylinder Ports may be reduced to ⅜" or ¼".**

**NOPAK**
**VALVES AND CYLINDERS**
**DESIGNED for AIR and HYDRAULIC SERVICE**

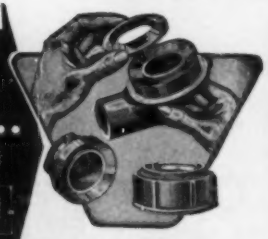
**Write for Bulletin SL**

**GALLAND-HENNING MFG. CO.**
2762 SOUTH 31ST STREET
MILWAUKEE 15, WISCONSIN

*Representatives in Principal Cities*

---

# SIMPLICITY of DESIGN...



**For Moving Pipe Lines**

# FLEXO JOINTS

**For safe, unrestricted flow, Flexo Joints offer the strength of pipe *plus* the flexibility of hose — to convey fluids through movable pipe lines or to equipment while in motion. Just four simple parts, completely enclosed—no springs—no small or loose parts . . . long wear—low maintenance. Four styles—standard pipe sizes ¼" to 3".**

***Write for complete information.***

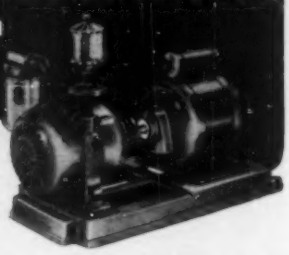
**FLEXO SUPPLY CO., Inc.**

**4650 Page Blvd. St. Louis, 13, Mo.**

**In Canada: S. A. Armstrong, Ltd., 1400 O'Connor Dr., Toronto 13, Ont.**

---

# BETTER LOOKING... better than ever!



# GAST rotary AIR PUMPS

***NOW*—THE SAME DEPENDABLE GAST ROTARY PUMPS + IMPROVED HOUSING DESIGN = FIVE EXTRA ADVANTAGES . . .**

1 — New fin housings provide greater cooling surface . . .
2 — Streamlined appearance, simpler, better looking . . .
3 — Same mounting dimensions . . . interchangeable with older Gast models . . .
4 — More compact than ever, total height is lower . . .
5 — Improved port design . . .

As original equipment, GAST rotary-design Air Pumps offer greater-than-ever values . . . in *improved salability for your product.* Air compressors in 5 sizes provide positive pressure range up to 30 P.S.I. — displacement to 21 C.F.M. Dry Vacuum Pumps in 5 sizes produce vacuum to 28 inches — displacement to 21 C.F.M.

**WRITE FOR NEW CONDENSED CATALOG — BULLETIN 549-A**

***"AIR may be your Answer!"***

**GAST ROTARY** AIR MOTORS • COMPRESSORS • VACUUM PUMPS
(TO ONE H.P.) (TO 30 CFM) (TO 28 INCHES)
GAST MANUFACTURING CORP., 130 Hubbard St., Benton Harbor, Mich.

# SMALLEST LIGHTEST FASTEST

# type 44 STEPPING SWITCH

***Up to 6 Levels — 10-point plus home; yet it's Smaller Than Your Hand!*** Only 4½ inches long—and about half that wide—Automatic Electric's new stepping switch averages only 13½ ounces in weight. Yet it gives you *more* than other larger switches.

*It's speedy* . . . a typical three-level 10-point switch, at 48 volts D. C., self-interrupted, runs approximately *80* steps a second—impulse controlled, at 35 steps a second.

*It's smoother* . . . brush springs are in an "11th" position; wipers pass over them exactly as over bank contacts. No double load in any position—no "galloping."

*It assures long life* . . . smooth operation means longer life; in addition, all driving parts are especially armored against wear. In rigid laboratory tests, Type 44 Stepping Switches averaged *20,000,000* operating cycles (200 million steps!) and then required only minor readjustment.

*It's adaptable* . . . meets your specific needs with a wide range of coils (for any D. C. voltage up to 110), bank levels, bridging and non-bridging wipers, interrupter springs and off-normal springs.

The Type 44 Stepping Switch has *less* weight—takes *less* space—and gives you *more* of everything else! Get complete data NOW on this revolutionary new switch. Call, wire, or write AUTOMATIC ELECTRIC SALES CORPORATION, 1033 W. Van Buren St., Chicago 7, Ill. In Canada: Automatic Electric (Canada) Limited, Toronto.

RELAYS SWITCHES

AUTOMATIC ELECTRIC

CHICAGO

The close-up view at the left shows actual lines of stress developed in gear teeth under load. *Photo taken in FAIRFIELD Gear Laboratory.*

## Helping to make a good product *Even Better!*

Polarized light used with photoelastic equipment to check stresses and strains in gear teeth is just one of the many steps Fairfield takes to help make good products even better! There is no finer recommendation for the quality of the product you sell than to be able to say that it is "Equipped with FAIRFIELD GEARS!" Long producers of the gears needed in high grade trucks and tractors, Fairfield now brings the same standards for gear performance to a wide variety of products: Road Graders . . . Machine Tools . . . Diesel Engines . . . and a host of others. Get acquainted with FAIRFIELD! Send for interesting, illustrated brochure.

**FAIRFIELD** — Power Gears

FAIRFIELD MANUFACTURING COMPANY
313 South Earl Avenue • Lafayette, Indiana

---

Specify **VIKING** For Your Future **PUMP PLANS**

Check today on your pumping equipment needs. Viking offers the most complete line in the rotary pump field. The range of sizes and styles are the largest available.

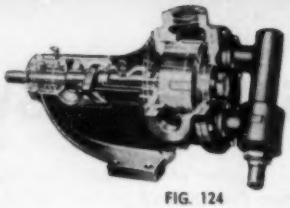


FIG. 124

Each is built to handle the specific job. Outstanding features include fast self priming . . . smooth, even discharge . . . low power requirements . . . compact and rugged construction.

*Send today for free bulletin 50SX.*

VIKING — AN HONORED NAME IN PUMPING

See Our Catalog in SWEETS

**Viking** Pump Company
Cedar Falls, Iowa

---

WORKS WHERE OTHERS WON'T

*accurately formed*

**GRAPHALLOY OILLESS BEARINGS**

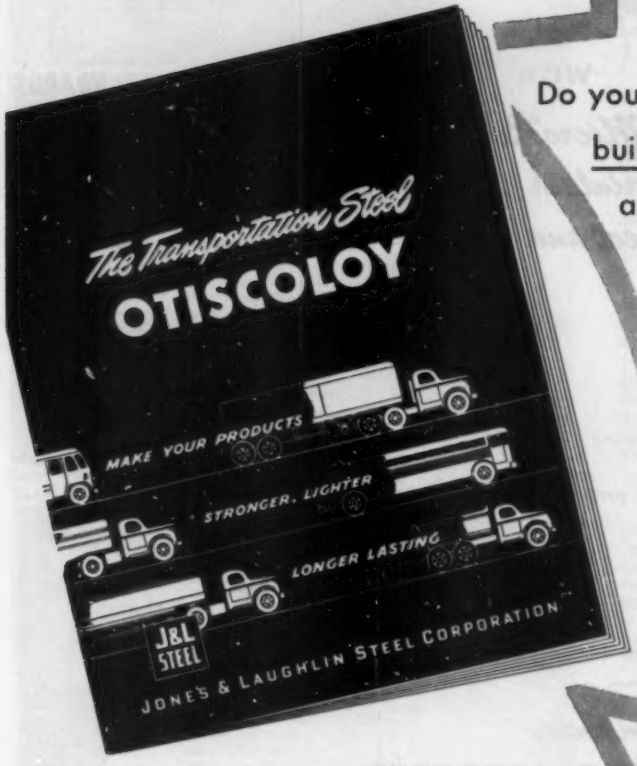
SPECIFY GRAPHALLOY WITH CONFIDENCE

SELF-LUBRICATING ● EXTREMELY DURABLE ● CONSTANT CO-EFFICIENT OF FRICTION ● OPERATES DRY — OR SUBMERGED IN WATER, GASOLINE OR CORROSIVE LIQUIDS ● APPLICABLE OVER A WIDE TEMPERATURE RANGE — even where oil solidifies or carbonizes ● EXCELLENT AS A CURRENT-CARRYING BEARING.

GRAPHITE METALLIZING CORPORATION
1012 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

# You can get this book FREE

J&L STEEL




Do you design, build or use any of these?

- TRUCKS
- BUSES
- ROAD MACHINERY
- RAILROAD CARS
- FARM MACHINERY
- SHIPS
- POWER SHOVELS
- CRANES
- MINING EQUIPMENT

Then mail this Coupon **TODAY**

This Free 32-page illustrated book may be worth a lot of money to you. It tells how you can fabricate *Otiscoloy* . . . how you can use it . . . gives you mechanical properties . . . and information on its high resistance to corrosion, abrasion and fatigue.

Structures of all kinds can be made *lighter—stronger—longer lasting* with "The Transportation Steel"—OTISCOLOY. Don't delay in learning how to put this high-tensile steel to work for you. The coupon is for your convenience.

**JONES & LAUGHLIN STEEL CORPORATION**

*From its own raw materials, J&L manufactures a full line of carbon steel products, as well as certain products in* OTISCOLOY *and* JALLOY *(hi-tensile steels).*

**PRINCIPAL PRODUCTS:** HOT ROLLED AND COLD FINISHED BARS AND SHAPES • STRUCTURAL SHAPES • HOT AND COLD ROLLED STRIP AND SHEETS • TUBULAR, WIRE AND TIN MILL PRODUCTS • "PRECISIONBILT" WIRE ROPE • COAL CHEMICALS

JONES & LAUGHLIN STEEL CORPORATION
409 Jones & Laughlin Building
Pittsburgh 30, Pa.

☐ Send me a free copy of "The Transportation Steel."

☐ Please have your salesman call, without obligation.

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

# that pot of gold is yours

WITH

## MicroRold Stainless Steel Sheet and Strip

**IF** you want stainless steel having

- ★ More area per ton

or

- ★ Equivalent area weighing 3% to 8% less

or

- ★ Unusually high physical properties

or

- ★ Reduced polishing costs

**AND**

**IF** you are interested in savings in cost of $152.00 per 100 sheets of polished 18 gauge _____

*use this coupon today*

**WASHINGTON STEEL CORPORATION**
**122 WOODLAND AVENUE**
**WASHINGTON, PENNSYLVANIA**

Please tell me more about

- ☐ MicroRold's savings in fabricating
- ☐ Savings in material costs

Name.....

Company.....

Address.....

City.....State.....

**WASHINGTON STEEL CORPORATION**
**122 WOODLAND AVENUE**
**WASHINGTON, PENNSYLVANIA**

## GETS STEADY HELP...

## ...From NEMA STANDARDS

Mr. John G. Tholke III, Electrical Engineer at Office of Hollis French, Boston, Massachusetts, tells us he uses McGRAW-HILL'S PRE-FILED ELECTRICAL CATALOGS "almost daily."

And, referring to the condensation of NEMA Standards on Motors and Generators which is pre-filed in the Catalogs, Mr. Tholke says:

*"The NEMA Standards have been particularly useful."*

This condensation is a 16-page section *edited especially for USERS*, to whom selection of motors and generators guided by NEMA Standards offers benefits such as: assurance of greater availability; more convenience in use; a sounder basis for accurate comparison; prompter repair service and shorter delivery time.

If PRE-FILED ELECTRICAL CATALOGS is not available for buying reference at your plant, write to McGRAW-HILL CATALOG SERVICE, 330 West 42nd Street, New York 18, N. Y. There is no charge to qualified users.

## Service PLUS!

Finest facilities available for modern efficient production line techniques on your sheet metal product or part.

Our expert field engineers are ready to discuss your problem in your plant.

**Maysteel PRODUCTS Inc.**

*Maysteel offers:*

- DESIGNING
- FABRICATING
- FINISHING

Send for FREE Idea Folder

**MAYSTEEL PRODUCTS, Inc.**
740 N. Plankinton, Room 712
MILWAUKEE 3, WISCONSIN

Modern Plants at MAYVILLE and SHEBOYGAN, WIS.

# Fighting Death

## ON THE HIGHWAYS

### *Telechron Timing Motors Help Reduce Driving Hazards*

The careless driver is not solely to blame for the daily accident headlines. The driver whose vision or reactions are poor is another grave threat to safety on the nation's highways.

To keep the traffic accident rate to a minimum, the American Automobile Association has since 1936 conducted an intensive program of driver testing and training. Numerous testing devices — for color vision, finger reaction, foot reaction, etc. — are employed, not only to rate a driver's ability but to impress on him the necessity for "defensive driving" to guard against the other fellow's faults.

And since the appliances used to test human reactions must be accurate to a split-second, they are actuated by Telechron Timing Motors. *Instantly, constantly synchronous*, these famous motors respond with accurate, dependable performance — every time!

### *How's YOUR Timing?*

If the control or recording of variables is your problem, very likely a standard Telechron Motor is your answer. A Telechron application engineer, backed by the broadest experience in the field, can help you decide that. For greatest savings in time and money, consult him as *early* as possible in your planning. Meanwhile, send the coupon for quick facts. TELECHRON INC. A General Electric Affiliate.

Telechron®

ALL TELECHRON TIMING MOTORS ARE

INSTANTLY...CONSTANTLY SYNCHRONOUS

**TELECHRON INC.**
10 Union Street
Ashland, Massachusetts

Please send me information on sizes and types of Telechron Synchronous Motors. My possible application is:

| | | | |
|---|---|---|---|
| Instruments | ☐ | Communications Equipment | ☐ |
| Timers | ☐ | Other (please fill in) | |
| Electric Appliances | ☐ | ..... | |
| Cost Recorders | ☐ | ..... | |
| Advertising, Display Items | ☐ | ..... | |
| Juke Boxes | ☐ | ..... | |
| Air Conditioning & Heating Controls | ☐ | ☐ Please send new Catalog | |

NAME .....

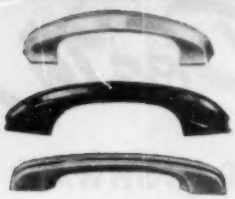
COMPANY .....

ADDRESS .....

CITY ..... ZONE .....

STATE .....

## Cut Your Costs with...



**GRIGOLEIT MOLDED PLASTICS**

**Stock Pulls, Knobs and Pendants**

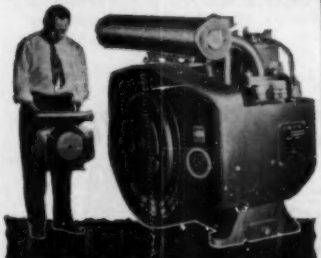
Modern molded plastics parts by Grigoleit give you a cost-cutting advantage . . . speed production . . . pep up sales!

*Write for complete catalog illustrating the many stock pulls, knobs and pendants available for prompt delivery.*

THE GRIGOLEIT COMPANY
"Over Twenty Years in Plastics"
541 E. NORTH ST. - DECATUR, ILLINOIS

---

*Lightweight*
## SMOOTH POWER



**ONAN** *twin-cylinder 4-cycle* **"CK" ENGINES**

The 97-pound, 10-horsepower, air-cooled "CK" engine meets the need for a prime mover combining weight-saving aluminum construction with heavy-duty performance and long life. Its smooth power, inherent in twin-cylinder-opposed, alternate-firing design improves the operation of any engine-driven equipment. The "CK" gives you 10 horsepower in *small* space, simplifying installation. Push-button or manual *instant* starting.

*Write for Specifications*

Onan **D. W. ONAN & SONS INC.**
6784 Royalston Minneapolis 5, Minn.

---

## BRUSH UP ON CALCULUS! . . .
with this practical refresher

THE entire subject of differential and integral calculus is offered here in easily-understood, readily-remembered question-and-answer form. 756 questions and their full and direct answers give you the complete essentials of this subject so necessary in solving technical problems.

## CALCULUS REFRESHER for TECHNICAL MEN

By A. ALBERT KLAF
*Civil engineer, Board of Water Supply, NYC*
*431 pages • 180 illustrations* • $3.50

This book makes available for rapid use the fundamental concepts, methods and practical applications of simple calculus. It is divided into three convenient sections.

**SECTION I** covers constants, variables, functions, limits, logarithms, etc.

**SECTION II** explains the fundamental ideas of integration; discusses mean value, length of an arc, center of gravity and the introduction to differential equations.

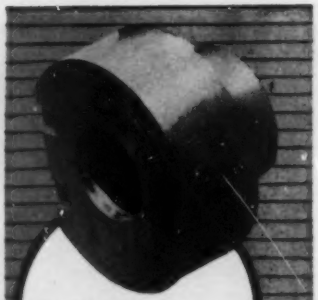
**SECTION III** is devoted entirely to practical problems involving calculus and arising in various technical fields.

**Mail coupon for FREE 10 Day Trial!**

McGraw-Hill Book Co., 330 W 42 St., NYC 18
Send me Klaf's CALCULUS REFRESHER for TECHNICAL MEN for 10 days' examination on approval. In ten days I will send $3.50, plus few cents for delivery or return the book. (We pay for delivery if you remit with this coupon. Same return privilege.)

Name .....
Address .....
City ..... Zone..... State.....
Company .....
Position ..... PTE-3-50

---



## *Here's a Better Bearing!*

American Crucible methods, experience, know-how and equipment result in highest quality and attractive savings to you.

Bearings, bushings and wearing parts, machined or rough cast from

**PROMET** Fine Engineered BRONZE

carry a
**MONEY-BACK GUARANTEE OF LONGER SERVICE AND LOWER MAINTENANCE COST**

Castings to your patterns—any size, shape or section up to 2,000 lbs. Pattern making, designing and machining.

**PROMET BRONZE BAR STOCK**

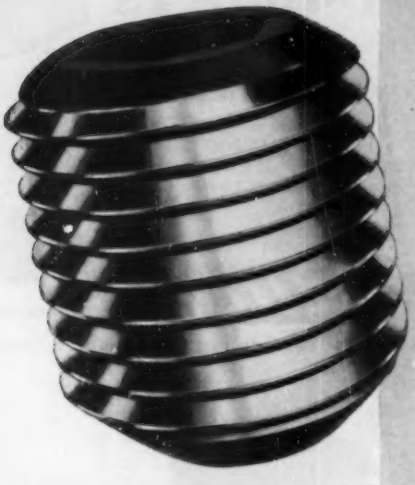
Round, solid or tubular. Rough cast or fully machined. Cored stock, all sizes (by ⅛" steps) from ½" minimum core to 10" O.D. and 12" lengths or less. Six grades of hardness.

Let us quote on your requirements and make recommendations as to alloys. Simply send blueprints, conditions of operation and other data.

**THE AMERICAN CRUCIBLE PRODUCTS CO.**
1317 Oberlin Ave.
Lorain, Ohio, U. S. A.

# Parker-Kalon GROUND THREAD Socket Set Screws

## SET RIGHT with SHOP MEN



**RIGHT START**

Quick starting, they speed assembly work and improve production.

**RIGHT FINISH**

Made from hardened stock, they have the smoothness of a true ground finish.

**RIGHT FIT**

Free from nicks, burrs and tool marks, they give you a dependable Class 3 Fit.

**RIGHT BUY**

More for the money—in quality—in performance—when you use P-K® Quality Controlled Socket Set Screws.

## SEE FOR YOURSELF!

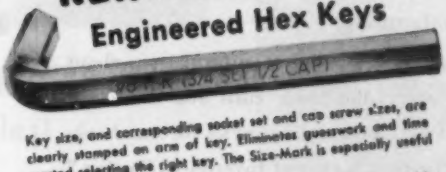
**Send for Samples.** Feel the difference thread grinding makes. Check the uniform Class 3 Fit. Notice how much smoother (and easier starting) Parker-Kalon Socket Screws are, the way they "set up" to dependable security. Once you try 'em, you'll use them regularly—to speed your assembly work. Write for samples today. Parker-Kalon Corporation, 200 Varick St., New York 14, N. Y.

*TRADE MARKS REG. U.S. PAT. OFF.

P-K

## PARKER-KALON* *cold-forged* SOCKET SCREWS

## NEW... Size-marked Engineered Hex Keys

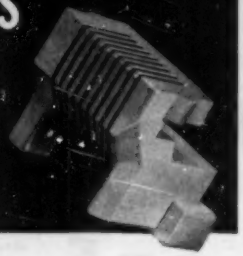



Key size, and corresponding socket set and cap screw sizes, are clearly stamped on arm of key. Eliminates guesswork and time wasted selecting the right key. The Size-Mark is especially useful in training new help.

➔ Parker-Kalon Engineered Hex Keys are again available in an attractive, compact steel case with easy-to-use key island (Set No. 111). Also available in a compact and durable plastic pouch (Set No. 45).

SIZE-MARKED SOCKET HEAD CAP SCREWS • GROUND THREAD SOCKET SET SCREWS • FLAT HEAD SOCKET CAP SCREWS • STRIPPER BOLTS • PIPE PLUGS • HEX KEYS • *AVAILABLE THROUGH ACCREDITED DISTRIBUTORS*

# Arwood skill made this bracket possible



ILLUSTRATED is a bracket with nine .040 slots, without draft, cast within a tolerance of .002, in relationship to each other and the base.

This bracket, considered impossible to make by any process other than precision casting, was a challenge in design to Arwood engineers. Making it exactly to specifications was possible only because of Arwood's perfection in tooling and its completely controlled manufacturing methods.

Perhaps you, too, have a production problem that Arwood can help you solve. Our engineers, with years of experience in many industries, often are able to make valuable suggestions that result in important savings in manufacturing.

For more complete information about the accuracy, the lower costs and the versatility of precision casting, write for our booklet, "A Critical Survey of Investment Casting."

**ARWOOD**

**PRECISION CASTING CORP.**

**68 WASHINGTON STREET • BROOKLYN 1, N. Y.**



PLUG TYPE

RECESSED TYPE

MUSHROOM TYPE

*every style and type*

# Rubber Bumpers

TACK BUMPER

**What do you need?**

Largest and most varied stocks in the U.S.A. UNUSUAL STYLES to meet every demand. Low cost and prompt delivery assured.

**FREE: 44 PAGE CATALOG**

Full data on all Mechanical and Industrial Rubber Goods. 36 Years Experience. Write Today. Catalog MS-46.

*Take it up with*

**LAVELLE** *Rubber Company*

1801 WEST HUBBARD STREET, CHICAGO 22, ILLINOIS

**LARGEST, MOST VARIED STOCK IN U.S.A.**

Every shape and size to meet your demand. Lowest possible cost per unit. Prompt shipment. Write, wire, or telephone your specifications, *today*.

**FREE· NEW 44 PAGE CATALOG**

Full data on all Mechanical and Industrial Rubber Goods. 36 years experience. Request Catalog MS-46 today.

*Take it up with*

**LAVELLE** *Rubber Company*

1801 WEST HUBBARD STREET, CHICAGO 22, ILLINOIS

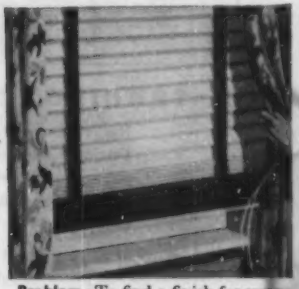
## This light used to fade!

**The Problem:** To find a way to keep the reflector surface on fluorescent lights from yellowing, so that the maximum amount of light would always be maintained.

**The Solution:** Industrial Finish Engineers developed a special mar-proof, baked finish that keeps its original whiteness and light reflectivity. Result: Customers get more light from fluorescent lights, with less electricity.

**Problem:** To find a finish for typewriters and other office equipment that would not reflect light and glare.

**Solution:** Industrial Finish Engineers developed a "wrinkle" finish that absorbs light—cuts down glare—is easily cleaned—and is not a dust catcher.



**Problem:** To find a finish for venetian blinds that would not flake off when the blind was raised.

**Solution:** Industrial Finish Engineers developed a finish that withstands impact of blinds being raised and lowered. It wipes clean . . . withstands rain and sun baking.

**Problem:** To find a finish for telephone receivers that would resist perspiration from user's hand.

**Solution:** In their laboratories, Industrial Finish Engineers developed a finish that was perspiration-resistant—withstands impact when person drops receiver on hook—is easily applied.

## Learn what Industrial Finish Engineers can do for your sales!

Here you have just a few fast examples of how Industrial Finish Engineering can and has brought more sales-appeal to many products.

Let it do the same for your product.

Find out if it can improve your sales—cut your manufacturing costs—help expand your market.

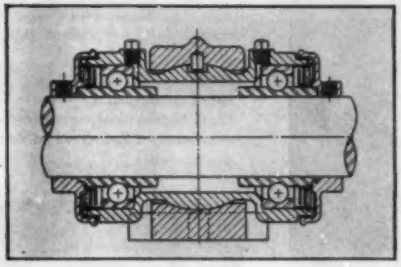
Any Industrial Finish Engineer can tell you. Consult one, today.

For the Finish Industry has technical ability to make finishes equal to the purpose for which each product is bought. Remember, most of your customers *start buying with the finish in mind.*

***The better the finish—The better the buy!***

© 1950. National Paint, Varnish and Lacquer Association, Inc., Washington, D. C.

**with BALL BEARINGS**
— the small extra first cost of test samples pays off in assurance of efficiency and durability of the finished mechanism.



**with TRACING CLOTH . . .**

The small extra first cost of Arkwright Tracing Cloth, over that of tracing paper, repays many times over in the efficiency and durability of valuable drawings.

Through continued research and development plus skilled manufacturing processes, Arkwright Tracing Cloths meet every requirement of exacting draftsmanship. You'll find no pinholes, stains or other imperfections to detract from drawing quality — nor smudging or feathering after repeated erasures. Most of all, you'll have highly transparent, long lasting usefulness that perishable tracing paper can never match.

*For every drawing worth keeping for future use* — specify permanent Arkwright Tracing Cloth. Send now for generous working samples. Sold by leading drawing material dealers everywhere. Arkwright Finishing Company, Providence, R. I.

***The Big Six Reasons Why Arkwright Tracing Cloths Excel***

1. Erasures re-ink without feathering.
2. Prints are always sharp and clean.
3. Tracings never discolor or go brittle.
4. No surface oils, soaps or waxes to dry out.
5. No pinholes or thick threads.
6. Mechanical processing creates permanent transparency.

**ARKWRIGHT**
**TRACING CLOTHS**
**AMERICA'S STANDARD FOR OVER 25 YEARS**

**PRECISION PERFECTION**

Diefendorf Gears are made to meet exacting engineering specifications . . . precision perfect in quality and performance.

All materials . . . all types of gears . . . made to specification only.

**DIEFENDORF GEAR CORPORATION**
Syracuse 1, New York

**DIEFENDORF GEARS**

**DO YOU KNOW?**

**—that a PILOT LIGHT CAN IMPROVE YOUR PRODUCT . . . add attraction—safety—service?**

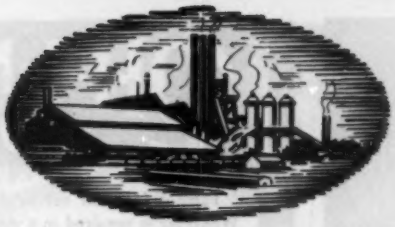
*Ask* DIALCO
*— what lamp to use*
*— how to use it*
*— what it will do*
*— what it will cost*

**THIS MAY BE THE ONE**
Designed for low cost NE-51 Neon
• Built-in Resistor • Patented
• U/L Listed • Rugged
Catalogue Number 521308 — 997 for 110 or 220 volts.

**SAMPLES for design purpose NO CHARGE**

*NEW!* Write for the "HANDBOOK OF PILOT LIGHTS."
Write us on your design problems.

*Foremost Manufacturer of Pilot Lights*
**The DIAL LIGHT COMPANY of AMERICA**
900 BROADWAY, NEW YORK 3, N. Y.



1900 ★ THE MIRACLE OF AMERICA ★ 1950

# Freedom and Progress

It's no stretch of the imagination, rather, robust realism to call our past half century a Miracle—U. S. A.

America has set an amazing record of progress in 50 years—but a moment in the history of civilization. A record unequalled by any other political or economic system.

Merely by broad brush strokes, we can all visualize this miracle. Remember the crystal set, the hand-cranked car, the biplane? A far cry from our FM radio, television, hydro-matic drive and supersonic planes.

And here's another phase of the miracle that went hand-in-hand with these and the myriad of intertwined technological advances—ranging from the radio telephone and Bakelite to the X-ray tube and teletype . . . and to atomic energy and its untold potentialities.

- ★ Since 1900 we have increased our supply of machine power 4½ times.
- ★ Since 1900 we have more than doubled the output each of us produces for every hour we work.
- ★ Since 1900 we have increased our annual income from less than $2400 per household to about $4000 (in dollars of the same purchasing power), yet . . .
- ★ Since 1900 we have cut 18 hours from our average work week—equivalent to two present average workdays.

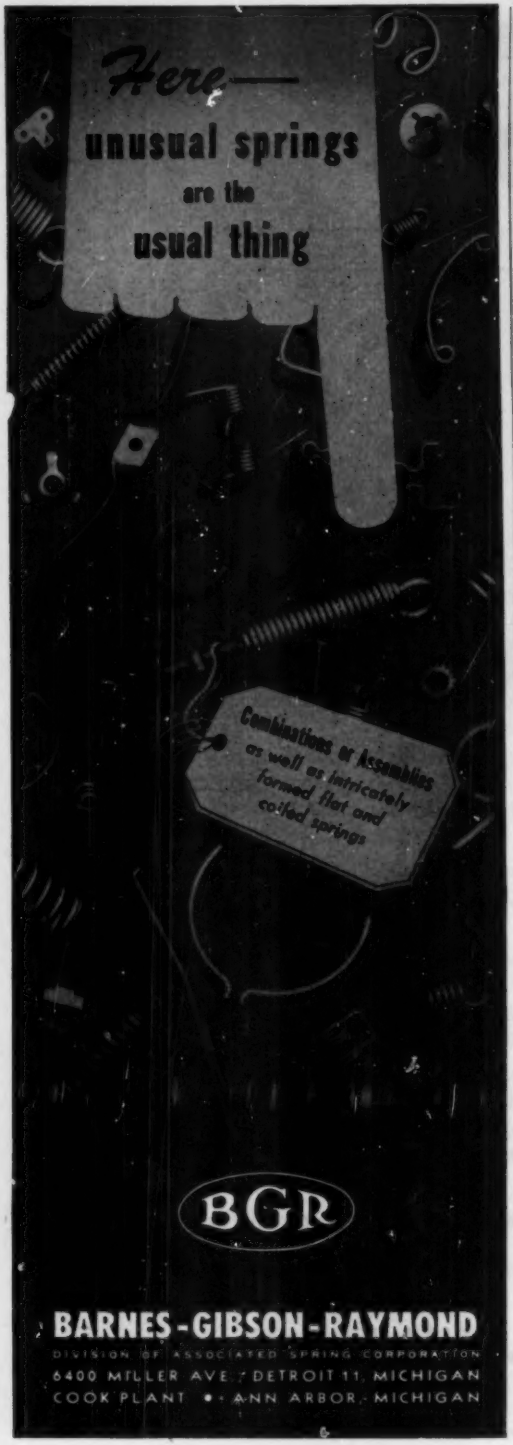
How did we do it? The basic cause for this composite miracle has been the release of human energy through FREEDOM, COMPETITION and OPPORTUNITY. And one of the most important results is the fact that more people are able to enjoy the products of this free energy than in any other system the world has ever known.

THIS IS THE MIRACLE OF AMERICA . . . it's only beginning to unfold.

A PUBLIC SERVICE PRODUCT — THE ADVERTISING COUNCIL

*Published in the public interest by:*

## McGraw-Hill Publications




KOH-I-NOOR PRODUCTS

The RIGHT pencil for the RIGHT job

Famous for their outstanding characteristics. Whatever is required in pencil performance will be found in our singularly commendable quality lines.

If it's KOH-I-NOOR you can be sure.

DRAWING PENCILS
COPYING PENCILS
WRITING PENCILS
CHECKING PENCILS
COLORED PENCILS
OFFICE PENCILS
ART PENCILS
HOLDERS and LEADS
PENHOLDERS and ERASERS

*Worlds change but KOH-I-NOOR quality remains.*

KOH-I-NOOR

SEE THE PIONEER
COOLANT AND LUBRICANT PUMPS
AT THE A.S.T.E. SHOW

PIONEER Pumps

PIONEER PUMP & MANUFACTURING CO.
19664 JOHN R STREET • DETROIT 3, MICHIGAN

CUSTOM BUILT MACHINERY
FOR OVER 75 YEARS

DIXIE-COWDREY
Machine Corporation

(A subsidiary of the Dixie Cup Co.)

Write:
DIXIE-COWDREY
Fitchburg, Mass.
Telephone: Fitchburg 5200

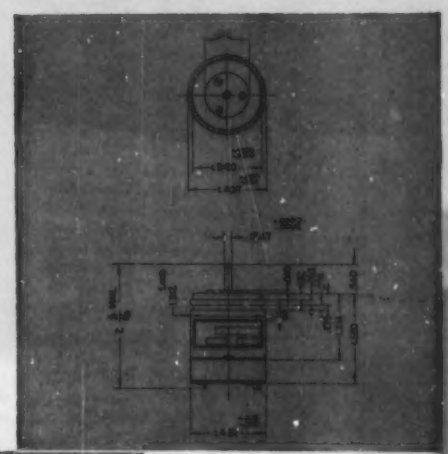
● DESIGNERS AND BUILDERS OF SPECIAL PURPOSE MACHINERY

# Announcing 6 MORE MINIATURE COMPONENTS

## ahead of demand for smaller, lighter, more accurate instrumentation units

## ARMA 03 SYNCHROS

**Here are the new Synchro Units Arma manufactures specifically to meet the demand for compact servo-mechanisms in modern instrumentation. They are designated as Arma's 03 Group and require 24 volt 400 cycle excitation.**



| Type | Drwg. No. | Freq. | Voltage Input | Voltage Output | Amps. | Watts | Static Accuracy | Rotor Inertia (oz. in.²) | Static Friction (oz. in.) | Weight (oz.) |
|---|---|---|---|---|---|---|---|---|---|---|
| 03G400 | 715646 | 400 | 24 | 24 | 0.065 | 0.40 | ±12′ | 0.05 | 0.5 | ¼ |
| 03DG400 | 715674 | 400 | 24 | 24 | 0.025 | 0.20 | ±12′ | 0.05 | 0.5 | ¼ |
| 03CT400 | 715648 | 400 | 24 | 24 | 0.025 | 0.20 | ±15′ | 0.05 | 0.1 | ¼ |
| 03DG400 | 787042 | 400 | 24 | 24 | 0.065 | 0.40 | ±30′ | 0.05 | 0.5 | ¼ |
| 03DDG400 | 787046 | 400 | 24 | 24 | 0.025 | 0.20 | ±30′ | 0.05 | 0.5 | ¼ |
| 03CCT400 | 787044 | 400 | 24 | 24 | 0.025 | 0.20 | ±30′ | 0.05 | 0.1 | ¼ |

### TYPICAL SPECIFICATIONS

The units of this group differ little except in electrical characteristics. They look alike and are of the same physical dimensions.

**SYNCHRO CATALOG JUST PRINTED GIVES COMPLETE DETAILS—ASK FOR A COPY**

## ARMA CORPORATION

254 36th STREET, BROOKLYN 32, N. Y.

SUBSIDIARY OF AMERICAN BOSCH CORPORATION

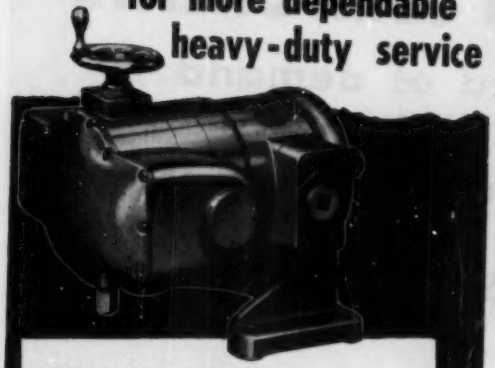
ARMA PRODUCTS RELEASED FOR PRIVATE INDUSTRY

ARMA ELECTRICAL RESOLVERS • ARMA SYNCHROS • ARMA INDUCTION MOTORS • ARMA INSPECTION GENERATORS • ARMA MECHANICAL DIFFERENTIALS • ARMA ALTERNATING VOLTAGE COMPARATOR • COMPUTING MECHANISMS • INDUSTRIAL CONTROLS • STABILIZATION DEVICES • NAVIGATIONAL EQUIPMENT • LIMITRON AUTOMATIC INSPECTION SYSTEMS

QUALITY ARMA INSTRUMENT PRECISION

# A *Rugged* PAIR

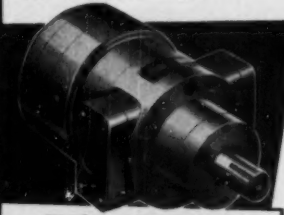
## for more dependable heavy-duty service



**DENISON VARIABLE VOLUME PUMPS** — You can depend on these 5000 psi pumps for longer, trouble-free service under all conditions! They feature axial-piston design and complete hydraulic balance, and are available in three sizes, with choice of hand-wheel, stem, pressure compensator, or cylinder control of pump volume. Volume deliveries up to 35 gpm. Also available in constant-volume types.

**DENISON CONSTANT VOLUME FLUID MOTORS** — Heavy-duty motors that withstand the abuse of toughest rotary drive requirements—even where frequent, sudden reversals at full rpm are called for. They are available in torque ranges up to 5000 pound-inches at speeds up to 3000 rpm, and are ruggedly built for long service, with minimum maintenance.

**DENISON HEAVY-DUTY TRANSMISSIONS** — Coupled together, the two units above form a highly efficient hydraulic transmission that meets the most rigid demands for dependable, low-cost service. Pump and motor are of the same basic, standardized design, featuring like components, and proved in performance. They are compact, powerful, high-torque units, with variable control of speed or torque.



**DENISON** also makes a complete line of directional and pressure controls for 5000 psi requirements. Write for full information on HydrOlic pumps, motors, valves, etc.

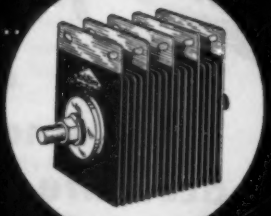
DENISON HydrOlics

The DENISON Engr. Co., 1157 Dublin Rd., Columbus 16, Ohio



# A Better Source of D.C. Power

with . . .



MAGNESIUM-COPPER SULPHIDE LIGHT WEIGHT "LEKTRON" RECTIFIERS

FOR:

SPOT WELDING

LAB. POWER SUPPLIES

FAST CHARGERS

ELECTRO-PLATING

AUTOMOTIVE AC GENERATORS

**The only rectifier with Magnesium Radiator Plates, "Lektron" is lighter in weight—handles up to 60 Volts D.C. from 50 to 50,000 Amperes. They're more rugged mechanically, operate at temperatures from —40° F to 284° F and are not affected by normal atmospheric conditions. Complete engineering service available.**

**Write for literature.**

Lektron Rectifiers

ELECTRONIC RECTIFIERS, INC.
2102 Spann Ave., Indianapolis 3, Indiana



# WILLIAMS

## DROP-FORGINGS

ANY SHAPE · ANY MATERIAL · COMPLETE FACILITIES

Write for Free Forging Data Folder . . . Helpful, Informative

J. H. WILLIAMS & CO., "The Drop-Forging People" BUFFALO 7, N.Y.

# STAMPINGS IN SMALL LOTS

PRECISION DIE MADE — LOWEST POSSIBLE COST

DAYTON ROGERS MFG. CO.

Minneapolis 7, Minnesota

# Practical design methods and procedures actually used in engineering design departments

EVERY design engineer has always wished for a compilation of design standards and methods of design procedure. Many engineering departments have gathered material of this kind which they call their standards manual.

The Editors of **Product Engineering** from the very first issue of the magazine gathered, compiled, checked and edited such reference sheets.

Now, in this one practical book, they have brought them all together in authoritative form for the use of all design engineers.

# HANDBOOK OF MECHANICAL DESIGN

*By* **GEORGE F. NORDENHOLT**
*Editor of Product Engineering*

**JOSEPH KERR**
*Assistant to the Editor of Product Engineering*

*and* **JOHN SASSO**
*Formerly Managing Editor, Product Engineering*

**285 pages, 8 x 11, 555 illustrations, $5.00**

A HANDY book of time-saving ideas and data for the designer of industrial machinery and equipment. Everything is boiled down to essentials and presented in concise, quick-use nomograms, charts, tables, check-lists, etc. Calculations, properties of materials, production factors of design, and similar material is well represented, and other chapters give a great many basic designs for fastenings, mechanisms, drives, controls, etc., readily adaptable to a wide number of applications. This is a book the engineer will use right at the drafting board, for quick, ready aid in scores of practical design problems.

Most of the book consists of material that has appeared in **Product Engineering**—special features of great popularity—here condensed, re-edited, and brought up to date, and brought together in convenient form.

### *Special Features*

A special feature is a chapter by S. A. Kilpatrick and O. J. Schaefer, of The Glen L. Martin Company, on stress calculations for thin aluminum sheet sections.

Other features are standard procedure in the design of springs, spring charts, methods for calulating belt drives, nomograms for engineering calculations, and the material on typical designs.

Over 500 illustrations are included, many of which are engineering drawings of design details with concise remarks on this distinctive features of use.

McGRAW-HILL
ON-APPROVAL COUPON

McGraw-Hill Book Company, Inc., 330 W. 42nd St., NYC 18, NY.
Send me Nordenholt, Kerr and Sasso's HANDBOOK OF MECHANICAL DESIGN for 10 days' examination on approval. In 10 days I will remit $5.00, plus few cents for delivery, or return the books. (We pay for delivery if you remit with this coupon; same return privilege.)

Name .....

Address .....

City ..... Zone..... State.....

Company .....

Position .....PPE-3-50

Books sent on approval in U. S. and Canada only.

## PRODUCT ENGINEER

Excellent opportunity with well-known Mid-western manufacturer of heavy mining and construction equipment for a qualified product engineer, experienced in the design of heavy diesel powered off the highway or related equipment.

Must be of proven ability with a minimum of 10 years experience, capable of assuming full responsibility for projects including the coordination of design with production and the supervision of technical personnel.

In reply please furnish complete resume of pertinent personal data, experience, availability, compensation desired and photo.

P-2454, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

## PRODUCT DESIGNER *Wanted*

Client seeks a product designer familiar with design and application of die castings in consumer and industrial products. The position open is for a consultant who would be available on a part time basis. Please send complete information on background and experience.

ALLIED ADVERTISING AGENCY, INC.
327 Ferguson Bldg., Cleveland 14, Ohio

## Engineers - Executives - Technical Men

Salaried Positions, $4,800 to $30,000. This Confidential service for men who desire a new connection, will develop and conduct preliminary negotiations without risk to present position. Send name and address for details.

TOMSETT ASSOCIATES
1206-2 Berger Bldg., Pittsburgh 19, Pa.

## Midwest manufacturer will diversify line. Will consider new products, in or out of automotive field. Address

CW-2414, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

## "AIR MAIL TRACINGS"

'Immediate service for all types of design engineering Chemical Plant Layout, steelwork etc. by an experienced Lady Tracer'. Send your requirements to

MRS. A. L. THOMAS,
'Deva', Vale Road, Hartford, Cheshire, England.

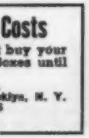
## TRANSPARENT PLASTIC MODELS

*for*

New product pilot working models
Polarized light stress analysis
Sales demonstration working models
*Send prints for estimates*
W. A. Haines, Box 371, Troy, Ohio

INSTRUMENT MANUFACTURERS

A Proportional divider having independently adjustable ends is now available on a non-exclusive licensing basis.



Patent #2487451
JOHN KURMER
4008 N. 13th St. Phila., 40, Pa.

## Reduce Your Shipping Costs

Closeouts on surplus stock—don't buy your Corrugated Cartons or Folding Boxes until you see us.

BERRY BOX CO., INC.
1913 Broadway Brooklyn, N. Y.
Tel. GLenmore 5-0402, 5908
*We also buy surplus cartons*

## WANTED MECHANICAL ENGINEER

with knowledge of storage battery manufacture. Location small Midwestern town—Replies confidential.

P-1949, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

*REPLIES (Box No.): Address to office nearest you*
*NEW YORK: 330 W. 42nd St. (18)*
*CHICAGO: 520 N. Michigan Ave. (11)*
*SAN FRANCISCO: 68 Post St. (4)*

### *POSITONS VACANT*

ELECTRICAL DESIGN Engineer: Fractional H.P. Induction motors, primarily shaded pole. 26-35 years old, 5 years experience. State education, experience, salary expected. Excellent opportunity with old established manufacturer. Location Western New York. P-2400, Product Engineering.

DESIGN AND Customer Contact Engineer for long-established New England Manufacturer of consumer goods. Must have creative ability in the application of customer specification to design and engineering of products involving primarily the fabrication and welding of small stainless steel parts. 35-45 preferable age range. Salary open. P-2181, Product Engineering.

### *SELLING OPPORTUNITY OFFERED*

MANUFACTURERS' REPRESENTATIVE — Sales potential of nationally advertised fastener line outgrowing present channels of distribution. We need alert, experienced sales organizations and agents calling on industrial trade. Advise territory and lines handled. RW-2467, Product Engineering.

### *EMPLOYMENT SERVICE*

SALARIED POSITIONS $3,500-$35,000. If you are considering a new connection communicate with the undersigned. We offer the original personal employment service (40 years recognized standing and reputation.) The procedure, of highest ethical standards, is individualized to your personal requirements and develops overtures without initiative on your part. Your identity covered and present position protected. Send only name and address for details. R. W. Bixby, Inc., 268 Dun Bldg., Buffalo 2, N. Y.

SALARIED PERSONNEL $3,000-$25,000. This confidential service, established 1927, is geared to needs of high grade men who seek a change of connection under conditions assuring, if employed, full protection to present position. Send name and address only for details. Personal consultation invited. Jira Thayer Jennings, Dept. H, 241 Orange St., New Haven, Conn.

### *POSITIONS WANTED*

MECHANICAL ENGINEER, Design, development new products, steel and aluminum. Knows manufacturing processes and costs. 28 yrs. experience. Capable Executive. Excellent sales record. PW-1595, Product Engineering.

MECHANICAL ENGINEER: Member of A.S.M.E.; age 43; married; Registered Graduate Engineer, now employed, desires change for a more responsible position as Mechanical or Assistant Chief Engineer. Twenty years of diversified mechanical experience involving Design, Testing, Patent Development, Inspection, and Administration Duties. Will travel if necessary. Address PW-2112, Product Engineering.

PATENT AND Development Engineer, 45, married, desires permanent position with medium-sized aggressive company, as Manager of Patent Department where outside counsel is retained. 24 years experience in diversified mechanical fields. Address reply to PW-2279, Product Engineering.

DESIGNER, 38, qualified to design or supervise designing of complete, medium weight machines, including mechanics, hydraulics, electricity, stress, gears, springs, fabrication, and styling. Specialized in simplified, practical designs. Good inventive record; 15 years experience; ample education. Midwest preferred. PW-2485, Product Engineering.

MECHANICAL ENGINEER, P.E. Nine Years broad experience in the design and development of special machinery and conveyors. Sound engineering background. Supervisory experience in the construction and maintenance of machinery. Location secondary to opportunity. PW-2474, Product Engineering.

## NEW ADVERTISEMENTS

Copy must be received by March 22nd to appear in the April issue.

# PROFESSIONAL SERVICES

**WILLIAM L. BROWN, 3rd**
*Product Engineering—Model Construction*
MINIATURE MECHANICAL OPERATING MODELS
Metals or Plastics
Complete Precision Tools and Instruments
6636 North Tenth St. Philadelphia 26, Pa.
Tel.: WAverly 4-1188

**THE CARLSON COMPANY**
*Spring Design Specialists*
MECHANICAL PRODUCT DEVELOPMENT
277 Broadway New York 7, N. Y.
Barclay 7-2552

**T. F. ESERKALN**
*Engineering Consultant*
Machine Design, Control Hydraulics, Product Development, Production Problems
2250 North Sixty-Second St. Phone
Milwaukee 13, Wisconsin Glenview 3-4296

**HERMAN LEWIS GORDON**
*Registered Patent Attorney*
Patent Investigations and Opinions
Warner Building 100 Normandy Drive
Washington 4, D. C. Silver Springs, Md.
NAtional 2497 SHepherd 2433

**GEORGE H. KENDALL**
*Consulting Mechanical Engineer*
Cost Reduction Studies: Process or Product.
Redesign Existing Products for Greater Profit.
Trouble Shooting Production, Design, Cost Problems,
Specialists Automatic Machinery, Processes, Controls,
New Developments, Patent Studies, Investigations,
New Products & Process Engineering Studies
P. O. Box 72 *(Est. 1923)* Tel. Darien 5-1504
Noroton Heights Darien, Connecticut

**NEW YORK TESTING LABORATORIES, INC.**
*CHEMICAL, MECHANICAL, ELECTRICAL METALLURGICAL ENGINEERS*
*ANALYTICAL CHEMISTS, PHYSICISTS, X-RAY*
Analysis, Tests of all Materials and Products, Plant and Field Services in Special Measurements of Stress, Sound, Vibration and other. Consultants in Litigation and Process Engineering and Design.
80 Washington St. New York City 6, N. Y.

**CHARLES VESELY & ASSOCIATES, INC.**
*Industrial Designers and Engineers*
Design Consumers Products
Engineering Commercial Equipment
Product Development Capital or Durable Goods
Office:
197-N. 123rd Street, Wauwatosa 13, Wisc.
Mem. ASME Mem. AIIE

**Consult these Specialists**

when you need professional assistance in solving difficult problems. Their specialized knowledge and broad experience can prove invaluable in saving both time and money for you.

## Index of PRODUCTS ADVERTISED In This Issue

### MATERIALS


Aluminum Alloys ....69–70–71–72–73 74–75, 242
Beryllium Alloys ..... 313
Bimetal ..... 280
Brass ..... 8, 26
Brazing Alloys ..... 253
Bronze ..... 238, 242, 309
Carbon Graphite ....4th Cover, 44–45
Cemented Carbides ..... 340
Copper Alloys .....2, 8, 26, 197, 256, 313
Felt ..... 268
Friction Materials ..... 169
Glass ..... 211
Laminated Metals .....64, 244
Leather .....48A–B
Liquids, Heavy ..... 66
Magnesium Alloys .....55, 69–70–71 72–73–74–75, 242
Manganese Alloys ..... 64
Molybdenum Alloys ..... 2
Nickel Alloys ....2nd Cover, 33, 241
Palladium Alloys ..... 2
Phosphor Bronze ..... 241
Plastics ....24, 43, 48D, 57, 65, 196, 213, 249, 250–251, 252
Plastics, Laminated .....200, 335
Platinum Alloys .....2, 64
Powdered Metals .....4th Cover 44–45, 169, 207
Rubber & Synthetics .....12, 48A–B, 196, 240, 249, 254
Silicones .....48, [illegible], 200, 211, 284
Silver Alloys ..... 2
Solders ..... 64
Stainless Steel ....30, 173, 181, 209, 305, 322
Steel .....76, 162, 175, 185, 209, 223, 317, 321
Tungsten Carbide ..... 2
Zinc ..... 201
Zinc-Coated Sheets ..... 162


### STRUCTURAL PARTS


Bars .....309, 321, 324
Bushings .....4th Cover 44–45, 222, 224, 309, 324
Castings .51, 69–70–71–72–73–74–75, 210, 221, 239, 242, 298, 305, 313, 324, 326
Coils .....162, 185
Die Castings ..16, 51, 55, 160, 199, 218, 226, 279, 302
Forgings ....51, 69–70–71–72–73–74 75, 284, 332
Metal Powder Parts .....4th Cover 44–45, 207, 222, 256, 282, 301
Plates .....69–70–71–72–73–74–75
Shapes .....183, 275, 321
Sheets .....162, 209, 321
Stampings ..... 76
Tubing .....69–70–71–72–73–74–75, 173, 175, 183, 195, 209, 217, 246–247, 290, 321
Weldments .....259, 269
Wire .....35, 185, 307, 321

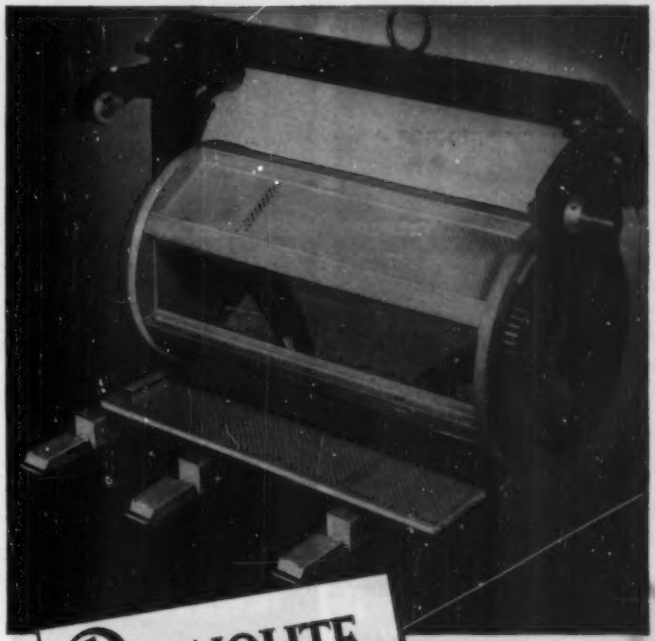

### FINISHES


Galvanizing .....206, 245
Paints & Lacquers .....245, 266–267, 282, 327
Rust Proofing .....233, 266–267


### MECHANICAL PARTS


Abrasives ..... 159
Accumulators ..... 341


*(Continued on page 336)*

PHENOLITE Laminated PLASTIC

Photo—Courtesy The Udylite Corporation—Detroit

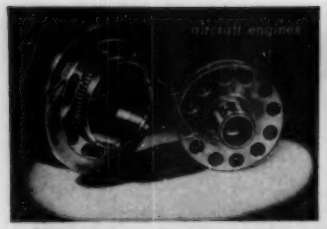
**The ideal material for plating barrels where high resistance to corrosion is a "must."**

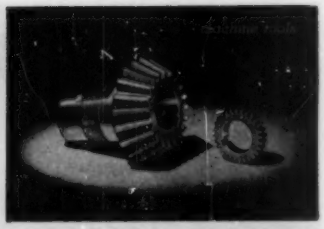
In the electroplating of metals, plating barrels must have high resistance to corrosion from the strong chemical solutions for efficient low-cost operation. In this role, Melamine Fabric Base Phenolite has proved to be very effective because of its exceptional resistance to chemical corrosion.

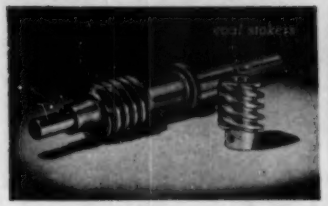
Phenolite, in addition to these important qualities, is light in weight, with high impact strength, excellent electrical insulating properties and one of the strongest materials per unit weight known. Phenolite has broad use in 'most every industry because of its remarkable combination of properties. Available in a broad group of grades—in Sheets, Rods, Tubes and Special Shapes.

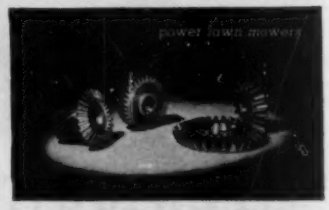
*National Service Engineers will, without obligation, assist you in utilizing Phenolite, National Vulcanized Fibre and Peerless Insulation to your best advantage.*

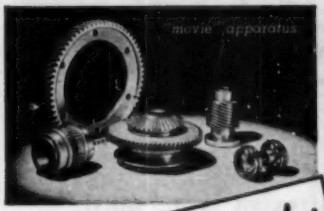
NATIONAL VULCANIZED FIBRE CO.
WILMINGTON DELAWARE
Offices in Principal Cities
Since 1873











*Typical Examples of* PERKINS custom-cut GEARS

**FOR A REPRESENTATIVE NUMBER OF MANUFACTURED PRODUCTS**

We have specialized in the mass production of precision gears to customers' specifications for nearly 30 years. Our equipment, facilities and experience enable us to fill orders for any type of gear in any quantity and material—metallic or non-metallic. Once your specifications are in our files, re-orders are filled automatically. Let us quote on your requirements now.

**YOU FURNISH THE SPECIFICATIONS — WE'LL PRODUCE THE GEARS**

# PERKINS Precision, Custom-Cut GEARS

PERKINS MACHINE & GEAR CO., West Springfield, Mass.


## Index of PRODUCTS ADVERTISED In This Issue

*(Continued from page 335)*


Air Motors ..... 318
Bearings, Ball, Roller, and Needle 25, 27, 32, 34, 48C, 77, 80, 194, 216, 224, 243, 264, 283
Bearings, "Oil-less" ..... 4th Cover 44–45, 222, 320
Bearings, Sleeve ..... 4th Cover 44–45, 221, 256, 301,309, 324
Bellows ..... 42, 179
Belts ..... 31, 169, 344
Bolts, Nuts, Screws and Rivets .. 10, 38, 177, 212, 215, 232, 272, 277, 288, 300, 325, 337
Bumpers ..... 326
Bushings & Grommets ..... 326
Cameras ..... 237
Carburetors ..... 274
Chains ..... 9, 14–15, 168, 60-61, 294, 298
Clamps ..... 202, 248
Cleaners ..... 266, 267
Clutches ..... 64B, 191, 198, 270, 310, 314
Compressors ..... 318
Controls ..... 248
Counters ..... 17
Couplings, Flexible ..... 14–15, 168, 60–61, 171, 208, 230, 270
Couplings, Hose & Tube .... 202, 236, 248, 252
Engines ..... 218, 308, 324
Fasteners ... 6, 10, 38, 40, 64, 69–70 71–72–73–74–75, 80, 177, 212, 215, 232, 272, 277, 300, 325, 337
Film ..... 257
Filters ..... 268, 274
Floats ..... 226
Furniture, Shop ..... 38
Gages & Instruments .... 18–19, 237, 248, 310
Gears ..... 14–15, 41, 62, 64A, 214, 262, 270, 275, 320, 328, 336
Hose ..... 217, 248, 260–261
Hydraulic & Pneumatic Equipment 64B, 167, 220, 229, 231, 238, 248, 255, 287, 293, 304, 306, 318, 332, 338
Insulation ..... 211, 249
Joints ..... 299, 318, 342
Lubricating Equipment ..... 203, 266, 267
Mountings ..... 230
Packing, Gaskets, Seals .... 4th Cover 27, 44–45, 47, 48A–B, 50, 169, 179, 271, 278, 296, 311
Power Units ..... 167, 231
Pumps ..... 167, 219, 229, 255, 280, 286, 293, 306, 318, 320, 330, 332, 338
Reels ..... 248
Regulators ..... 248
Screw Machine Parts ..... 38, 69–70–71–72–73–74–75, 212
Seal Rings ..... 4th Cover
Shafts ..... 272, 339
Sheaves & Pulleys .... 20–21, 31, 270
Shims ..... 244
Speed Reducers & Motor Reducers 3rd Cover, 13, 20–21, 28–29, 225, 252, 262, 270, 276, 336
Springs ..46, 54, 204, 297, 307, 330
Strainers ..... 248
Testing Equipment ..... 18–19
Tapes ..... 22, 316
Thermostats ..... 49, 179
Timers ..... 208

## Index of PRODUCTS ADVERTISED In This Issue

Transmissions ..... 9, 13, 15, 168, 20–21, 28–29, 31, 41, 648, 252, 255, 270, 294, 298, 332
Traps ..... 226
Universal Joints ..... 238, 306
Valves & Fittings ..... 189, 220, 236, 238, 248, 255, 278, 299, 304, 306, 318, 342
Vibration Dampers ..... 230, 240
Washers ..... 40, 212
Wheels & Casters ..... 212, 278
Wire Cloth ..... 187, 307, 308

### ELECTRICAL PARTS

Brakes ..... 59
Brushes ..... 4th Cover, 44-45, 278
Clutches ..... 59
Connectors ..... 63
Contacts ..... 2, 64, 68, 274, 288
Controls & Control Equipment ..... 2, 36-37, 52–53, 68, 96A–B, 192, 193, 206, 208, 234–235, 263, 282, 298, 319, 331, 343
Drives ..... 273, 312
Electronic Equipment ..... 18–19, 68
Generators ..... 331
Heating Units ..... 18–19, 56
Instruments ..... 18–19
Insulators ..... 304
Lamps ..... 328
Magnetos ..... 67
Motors ..... 3rd Cover, 11, 18–19, 32A-E, 39, 58, 205, 225, 252, 273, 281, 285, 286, 289, 303, 310, 312, 315, 316, 323, 331
Rectifiers ..... 2, 68, 332
Solenoids ..... 96A–B, 278, 298, 318
Thermostats ..... 49, 343
Timers ..... 208, 228, 323
Vibration Exciters ..... 291
Wiring Accessories ..... 63, 308

### DRAFTING ROOM EQUIPMENT AND SUPPLIES

23, 214, 237, 257, 280, 328, 330

### FABRICATING METHODS AND SERVICES

Brazing ..... 253
Coating ..... 233, 266-267
Die Making ..... 265
Drawing ..... 265
Engraving ..... 304
Extruding ..... 314
Finishing ..... 265, 322
Forming ..... 265
Hardening ..... 265
Heating ..... 265
Milling ..... 304
Molding ..... 16A, 249, 250-251, 295 296, 304, 314, 324
Photographing ..... 237, 257
Pressing ..... 76, 245, 265, 292
Rolling ..... 265
Shearing ..... 265
Spinning ..... 312
Stamping ..... 76, 245, 249, 265
Welding ..... 2, 68, 227, 245, 259, 265 269, 313
X-Raying ..... 245

### ENGINEERING AND PRODUCTION SERVICES

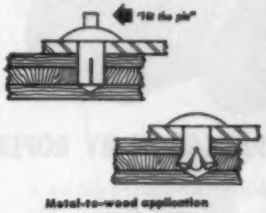
4, 204, 227, 237, 245, 257, 265, 269 314, 322, 330

### BOOKS

286, 300, 302, 312, 321, 322, 324 333

by industry
for rapid, low-cost installation

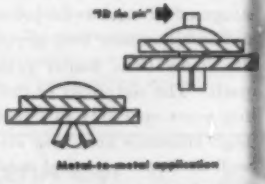
# SOUTHCO DRIVE RIVETS




Metal-to-wood application

Designed with low-cost mass-production methods in mind, SOUTHCO Drive Rivets are installed in the least possible time. One man working from one side of the job makes quick application—there's no bucking, no trimming, no finishing—that's an ideal blind installation.

SOUTHCO Drive Rivets are installed *with a hammer*—no special tools necessary! You do away with costly guns and cumbersome equipment. Production costs drop as man-hours are saved.




Metal-to-metal application

The SOUTHCO rivet consists of a slotted tubular rivet with inserted grooved pin. Expanding prongs exert real "pull-up", drawing panels together for a tight, rigid joint. Available from stock in modified brazier and 100° countersunk head styles.

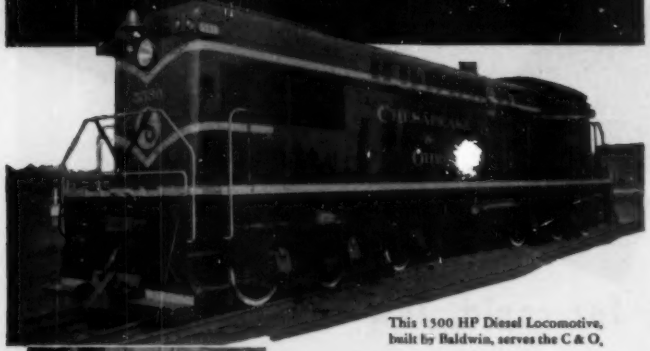
Write today for free illustrated handbook of SOUTHCO Fastening Specialties.

SOUTH CHESTER CORPORATION
1406 Finance Building
1418 South Penn Square
Philadelphia 2, Pa.

SOUTHCO

# ROPER Rotary PUMPS

**DELIVER LUBRICATING OIL ON BALDWIN ROAD-SWITCHING LOCOMOTIVES...150 G.P.M. at 100 P.S.I.**



This 1500 HP Diesel Locomotive, built by Baldwin, serves the C & O.

Close-up of the special Roper pump which is located at the front left-hand side of the Diesel Engine. The pump is chain driven.

## A TYPICAL "CUSTOM-BUILT" APPLICATION BY ROPER

This custom-built pump — made to deliver lubricating oil on a Baldwin Diesel Switching Locomotive — is typical of a wide range of tailored-to-the-job units produced by Roper. Although applications may vary greatly, each custom pump is designed along the basic Roper principle employing only two moving parts. The simplicity of this design — equal size, helical pumping gears operating in a case with proper clearance — promotes high efficiency and long service life. Roper custom-built — as well as Roper standard models — can effect substantial savings in the long run. Sizes range from 3/4 to 300 G.P.M. — pressures up to 1000 P.S.I.

*Send For Descriptive Literature*

**GEO. D. ROPER CORP.**
**373 Blackhawk Park Ave.**
**ROCKFORD, ILLINOIS**

ROPER Rotary Pumps

DEPENDABILITY SINCE 1857


## INDEX TO ADVERTISERS

*This index is published as a convenience to the readers. Every care is taken to make it complete, but PRODUCT ENGINEERING assumes no responsibility for errors or omissions.*


Accurate Spring Mfg. Co..... 204
Aeroquip Corp. ..... 236
Alemite ..... 203
Allegheny Ludlum Steel Corp.... 305
Allen-Bradley Co. .....296A-B
Allis-Chalmers Mfg. Co.....11, 31
Allmetal Screw Products Co., Inc. ..... 212
Aluminum Co. of America 69, 70, 71, 72, 73, 74, 75
Aluminum Goods Mfg. Co..... 265
Aluminum Industries, Inc..... 51
American Brass Co..... 197
American Chain & Cable Co., Inc., Page Steel Wire Div..... 244
American Crucible Products Co.. 324
American Hard Rubber Co..... 196
American Hot Dip Galvanizers Assn. ..... 206
American Manganese Bronze Co. 238
American Metal Hose Branch, American Brass Co..... 217
American Screw Co..... 10
American Steel & Wire Co...35, 46
American Welding & Mfg. Co... 259
Arkwright Finishing Co..... 328
Arma Corp. ..... 331
Armco Steel Corp..... 162
Armstrong Cork Co. (Gaskets, Packings & Seals)..... 47
Arwood Precision Casting Corp.. 326
Auburn Button Works Inc..... 314
Austenal Laboratories, Inc..... 239
Automatic Electric Corp..... 319
Automotive Gear Works Inc..... 64A

Bakelite Division, Union Carbide and Carbon Corp....48D, 65
Barco Mfg. Co..... 299
Barnes Co., Wallace, Div. Associated Spring Corp..... 54
Barnes-Gibson-Raymond Div., Associated Spring Corp. ..... 330
Beryllium Corp. ..... 313
Bethlehem Steel Corp..... 223
Blood Brothers Machine Co..... 238
Boundbrook Oil-less Bearing Co.. 222
Bridgeport Brass Co..... 26
Brown Instrument Co..... 263
Brown & Sharpe Mfg. Co..... 219
Bundy Tubing Co.....246-247
Bunting Brass & Bronze Co..... 309

Cambridge Wire Cloth Co..... 308
Carboloy Co., Inc..... 340
Carlyle Johnson Machine Co..... 191
Carpenter Steel Co..... 30
Cash Valve Mfg. Corp., A. W... 238
Chase Co., W. M..... 280
Chain Belt Co.....14-15
Chicago Metal Hose Corp....260-261
Chicago Rawhide Mfg. Co.....48A-B
Chiksan Co. ..... 342
Clare & Co., C.P.....234-235
Cleveland Cap Screw Co..... 232
Clifford Mfg. Co..... 42
Colorado Fuel & Iron Corp. Wickwire Spencer Steel Div... 307

# INDEX TO ADVERTISERS


Cramer Co., Inc., R. W. ..... 208
Crane Co. ..... 189
Curtis Universal Joint Co. ..... 306

Dayton Rogers Mfg. Co. ..... 332
Delco Products Div., Gen. Motors Corp. ..... 281
Denison Engineering Co. ..... 332
Diel Light Co. of America ..... 328
Diefendorf Gear Corp. ..... 328
Dixie Cowdrey Machine Corp. ..... 330
Dodge Mfg. Corp. ..... 28-29
Doehler-Jarvis Corp. ..... 16
Dow Chemical Co. ..... 43, 55, 66
Dow Corning Corp. ..... 158
Drop Forging Association ..... 284
duPont de Nemours & Co., Inc., E. I. (Plastics) ..... 24
Durakool, Inc. ..... 206

Eastman Kodak Co., Industrial Functional ..... 237
Eastman Kodak Co., Industrial Photographic ..... 257
Eaton Mfg. Co., Reliance Spring Washer Div. ..... 40
Electric Auto-Lite Co. ..... 160
Electric Boat Co., Electro Dynamic Div. ..... 285
Electric Wheel Co. ..... 212
Electro Dynamic Div., of Electric Boat Co. ..... 285
Electronic Rectifiers, Inc. ..... 332
Emerson Electric Mfg. Co. ..... 315

Fafnir Bearing Co. ..... 243
Fairfield Mfg. Co. ..... 320
Farrel-Birmingham Co., Inc. ..... 276
Fawick Airflex Co., Inc. ..... 198
Federal Bearings Co., Inc. ..... 34
Federal Mogul Corp. (Equipment) 256
Fenwal, Inc. ..... 343
Flexo Supply Co., Inc. ..... 318
Foote Bros. Gear & Machine Corp. ..... 41
Formica Insulation Co. ..... 200
French & Hecht, Inc. ..... 278
Fulton Sylphon Div., Robertshaw—Fulton Controls Co. ..... 179

Galland-Henning Mfg. Co. ..... 318
Garlock Packing Co. ..... 311
Gast Mfg. Corp. ..... 318
Gear Specialties ..... 62
General American Transportation Corp. Plastics Div. ..... 250-251
General Electric Co., Apparatus Dept. ..... 18-19, 32A-B, 56
General Electric Co., Silicones Chemical Div. ..... 48
General Plate Co. ..... 64
Gerotor May Corp. ..... 306
Gibson Electric Co. ..... 274
Gleason Works ..... 4
Goodrich Chemical Co., B. F. (Geon) ..... 12
Goodrich Co., B. F. (Rivnut) ..... 6


*(Continued on page 340)*


## QUICK FACTS *about* S.S.WHITE FLEXIBLE SHAFTS

They are made in two classes:

**POWER DRIVE**—For transmitting rotary power to instruments and other mechanisms from small motors or other power sources.

**REMOTE CONTROL**—For the control of parts that require automatic or manual adjustment from a remote point. Remote control shafts are engineered for smooth, sensitive control because they have minimum torsional deflection, approximately equal deflection in either direction of rotation and low internal friction.

**FLEXIBLE CASINGS**—Serve as runways to prevent "helixing", to protect the shaft and to retain lubricant. Casings are metallic, fabric-covered and rubber-covered depending on the service.

**END FITTINGS** — for connecting shafts and casings are available for almost any shaft application.

**S.S.WHITE SHAFT AND CASING COMBINATIONS** can be supplied in a wide range of diameters and physical characteristics in lengths to suit your requirements. The cooperation of S.S.White engineers in working out the most suitable combination is yours without obligation.

**SEND FOR BULLETIN 4501**

It gives basic facts about the selection and application of flexible shafts. Write for free copy today.

**S.S.WHITE INDUSTRIAL DIVISION**
THE S. S. WHITE DENTAL MFG. CO. — DEPT. D — 10 EAST 40th ST., NEW YORK 16, N. Y.
FLEXIBLE SHAFTS AND ACCESSORIES
MOLDED PLASTICS PRODUCTS—MOLDED RESISTORS
*One of America's AAAA Industrial Enterprises*

# Your machine and product parts Work Better · Last Longer

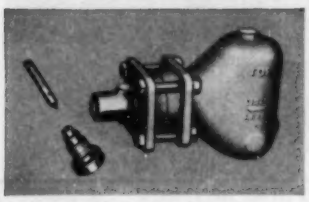
## when made of Carboloy Cemented Carbide

*(a powdered metal)*

**For Carboloy's** unusual combination of versatile and useful properties provides answers to most product or process wear problems. Each case history application has revealed an astounding story of increased machine part or product life . . . increases of as high as several hundreds of times . . . directly attributable to one or more of these characteristics of Carboloy Cemented Carbide:

1. **Hardness**
2. **Compressive strength**
3. **Abrasion resistance**
4. **Corrosion resistance**
5. **High red hardness**
6. **Low coefficient of thermal expansion**
7. **High modulus of elasticity**
8. **Impact strength**
9. **High density**
10. **High polish retention**
11. **Low electrical conductivity**
12. **Non-magnetic (if desired)**

**Some Typical Accomplishments of this Miracle Metal**



**A thousand lives** and more were added to these valve stems and seats when they were made of Carboloy. Now they stand up under wear from abrasive fluids, have greater corrosion-resistance to paints.

**A thousand uses** . . . uses like this. Automatic screw machine bushings of Carboloy, used on Swiss-type machines, reduce wear and increase bushing life many times—with increases in production efficiency.

**Thousands of Manufacturers Have Discovered New Uses for this Metal of a Thousand Lives! How About You?**

Why not find out for yourself how Carboloy, in your machine or product parts, can save you money and still improve product quality? Contact our engineers; they'll be glad to show you, without obligation, how Carboloy can be put to work for you. Carboloy Company, Inc., 11105 E. 8 Mile Road, Detroit 32, Michigan.

WHEREVER THERE'S MOTION THERE *need not be* ~~MUST~~ WEAR

**CARBOLOY®** CEMENTED CARBIDE **HARD METAL**

***The Versatile Metal of Industry***


## INDEX TO ADVERTISERS

*(Continued from page 339)*


Graphite Metallizing Corp. . . . . 320
Greer Hydraulics, Inc. . . . . 341
Gries Reproducer Corp. . . . . 226
Grigoleit Co. . . . . 324

Handy & Harman. . . . . 253
Hannifin Corp. . . . . 220, 298
Hansen Mfg. Co., Inc. . . . . 286
Harper Co., H. M. . . . . 215
Haydon Mfg. Co. . . . . 228
Heim Co. . . . . 32
Hilliard Corp. . . . . 314
Holliston Mills, Inc. . . . . 214
Holtzer-Cabot, Division of National Pneumatic Co., Inc. . . 58
Hoover Ball & Bearing Co. . . . . 216
Hoover Co., Kingston-Conley Div. 303
Houghton & Co., E. F. . . . . 50
Hyatt Bearings Div., General Motors Corp. . . . . 25
Hydraulic Equipment Co. . . . . 293

Imperial Tracing Cloth Co. . . . . 280
International Nickel Co., Inc., Monel . . . . . 33
International Nickel Co., Inc., Nickel Alloy . . . . . 2nd Cover

Jeffrey Mfg. Co. . . . . 294
Johns-Manville Corp. . . . . 271
Johnson Bronze Co. . . . . 301
Johnson Machine Co., Carlyle. . . . 191
Jones & Laughlin Steel Corp. . . . 321
Jones Foundry & Machine Co., W. A. . . . . 270

Kaydon Engineering Corp. . . . . 264
Keuffel & Esser Co. . . . . 22-23
Koh-I-Noor Pencil Co., Inc. . . . . 330
Kohler Co. . . . . 218
Koppers Co., Inc. (Fast's Coupling) . . . . . 171
Koppers Co., Inc., Plastics Div. . . . 213
Koven & Bros. Inc., L. O. . . . . 245
Kurz-Kasch, Inc. . . . . 295

Lamb Electric Co. . . . . 289
Laminated Shim Co. Inc. (Laminum) . . . . . 244
Laplant-Choate Mfg. Co. . . . . 231
Lavelle Rubber Co. . . . . 326
Leach Relay Co. . . . . 282
Lincoln Electric Co. . . . . 227
Linear, Inc. . . . . 296
Link-Belt Co. . . . . 9, 13
Litemetal Dicast, Inc. . . . . 302
Logansport Machine Co., Inc. . . . 304
Lord Mfg. Co. . . . . 230
Lukens Steel Co. (Clad Steel). . . 317

McGill Mfg. Co., Inc. . . . . 194
McGraw-Hill Book Co. Inc. . 286, 300, 302, 312, 324, 333

# INDEX TO ADVERTISERS


McGraw-Hill Catalog Service .... 322
M. B. Mfg. Co., Inc. .... 291
Maas & Waldstein Co. .... 282
Madison-Kipp Co. .... 199
Magnetrol Valve Corp. .... 278
Mahon Co., R. C. .... 269
Mallory & Co., Inc., P. R. .... 2, 68
Manheim Mfg. & Belting Co. .... 344
Marman Products Co. Inc. .... 202
Marsh Corp., Jas. P. .... 310
Master Electric Co. (Speedmaster) .... 3rd Cover
Maysteel Products, Inc. .... 322
Michigan Steel Tube Products Co. 195
Micro Switch Div. of First Industrial Corp. .... 52–53
Midland Steel Products Co. .... 288
Mills Corp., Elmer E. .... 16A
Minnesota Mining & Mfg. Co. .... 233
Monsanto Chemical Co. .... 57
Moraine Products Div. General Motors Corp. .... 207
Morganite, Inc. .... 278
Mt. Vernon Die Casting Corp. .... 279

National Bearing Div., Amer Brake Shoe Co. .... 221
National Motor Bearing Co., Inc. 27
National Paint, Varnish & Lacquer Association Inc. .... 327
National Screw & Mfg. Co. .... 300
National Vulcanized Fibre Co. .... 335
New Departure Div. Gen. Motors Corp. .... 80
New Hermes, Inc. .... 304
New Jersey Zinc Co. .... 201
Nicholson & Co. W. H. .... 226
Norma-Hoffman Bearing Corp. .... 283

Oilgear Company .... 255
Onan & Sons, Inc. .... 324
Owens Corning Fiberglas Corp. .... 211

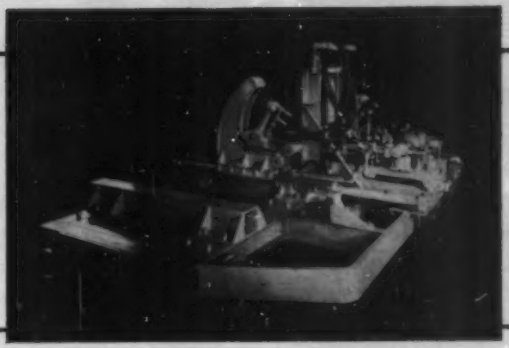
Page Steel & Wire Div., Amer. Chain & Cable Co., Inc. .... 244
Parker-Kalon Corp. .... 277, 325
Parker Rust Proof Co. .... 266-267
Patton-MacGuyer Co. .... 308
Peerless Electric Co. .... 310
Perkins Machine & Gear Co. .... 336
Pesco Products .... 229
Philadelphia Gear Works .... 262
Phoenix Products Co., Metal Spinning Div. .... 312
Pioneer Pump & Mfg. Co. .... 330
Powdered Metal Products Corp. .. 282
Pneu-Trol Devices, Inc. .... 306
Pure Carbon Co., Inc. .... 258

R.B.M. Division of Essex Wire Corp. .... 288
Racine Tool & Machine Co. .... 286
Ramsey Chain Co., Inc. .... 298
Rathbone Corp. .... 275
Raybestos Manhattan Inc., Equipment Sales Div. .... 169


*(Continued on page 342)*


## REMOTELY CONTROLLED POWER FROM GREER ACCUMULATOR

- **Reduces Horsepower Requirement**
- **Saves Time**
- **Eliminates Need for Operator on Carriage**



**Huge Hydraulic Pulpwood Carriage and Greer Accumulator.**
Photo Courtesy of the Filer & Stowell Co., Milwaukee, Wisconsin

VINCENT R. NOLL
The Filer & Stowell Co.
Milwaukee, Wisconsin . . .

*"Filer & Stowell Hydraulic-operated carriages handle 10-ton logs with ease. Two 1000 psi pumps actuate the set cylinders to position the log and to store fluid under pressure in a Greer 5-gallon accumulator. This stored power is released instantaneously to the dog cylinders for gripping the log. Precious time is saved over the same operation where an accumulator is not used. Moreover, accumulator pressure urges the tong dogs toward the closed position, automatically holding the log after it has been dogged. The pumps are then released for use in other operations such as: setting, tapering, or receding."*

*"In addition, remote control of fluid power made possible by the Greer Accumulator, enables us to eliminate the use of one operator on the carriage. The net result is a reduction in horsepower requirement and a saving of time and manpower."*

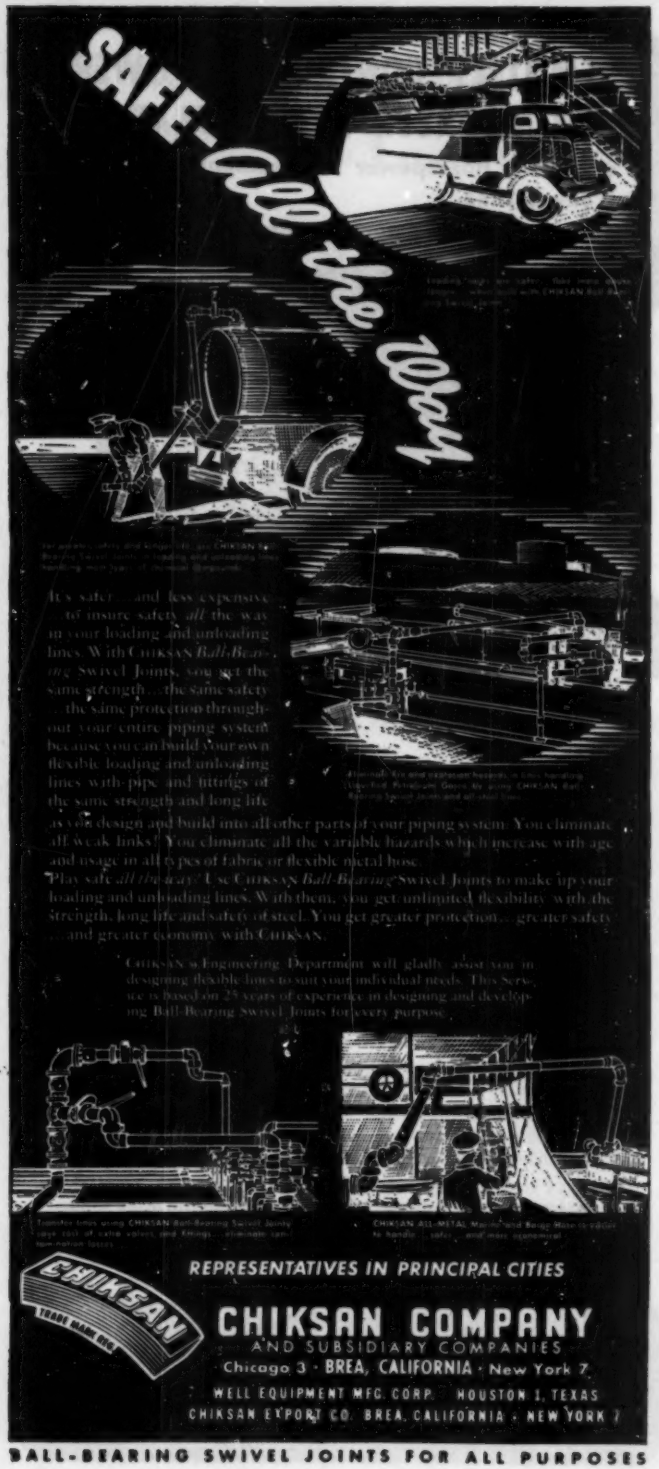
This is just one of the numerous installations where Greer Accumulators are effecting greater economy, increased production and improved operation efficiency of processes and machines.

If you are now using or plan to use hydraulic equipment, it will pay you to discover what our accumulator can do for you.

We, at Greer, are eager to discuss your particular hydraulic problems. A request for information on your company letterhead will bring an immediate reply. Write Now!

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

YOUR SYMBOL OF SERVICE
GREER
HYDRAULICS INC.
454 EIGHTEENTH ST., BROOKLYN 15, N. Y.


SAFE-all the way
It's safer ... and less expensive ... to insure safety all the way in your loading and unloading lines. With CHIKSAN Ball-Bearing Swivel Joints, you get the same strength ... the same safety ... the same protection throughout your entire piping system because you can build your own flexible loading and unloading lines with pipe and fittings of the same strength and long life as you design and build into all other parts of your piping system. You eliminate all weak links! You eliminate all the variable hazards which increase with age and usage in all types of fabric or flexible metal hose.
Play safe all the way! Use CHIKSAN Ball-Bearing Swivel Joints to make up your loading and unloading lines. With them, you get unlimited flexibility with the strength, long life and safety of steel. You get greater protection ... greater safety ... and greater economy with CHIKSAN.
CHIKSAN's Engineering Department will gladly assist you in designing flexible lines to suit your individual needs. This service is based on 25 years of experience in designing and developing Ball-Bearing Swivel Joints for every purpose.
REPRESENTATIVES IN PRINCIPAL CITIES
CHIKSAN
TRADE MARK REG.
CHIKSAN COMPANY
AND SUBSIDIARY COMPANIES
Chicago 3 · BREA, CALIFORNIA · New York 7
WELL EQUIPMENT MFG. CORP. HOUSTON 1, TEXAS
CHIKSAN EXPORT CO. BREA, CALIFORNIA · NEW YORK 7
BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

# INDEX TO ADVERTISERS

*(Continued from page 341)*


Raymond Mfg. Co., Div. Associated Spring Corp. ..... 297
Reeves Pulley Co. ..... 20-21
Republic Steel Corp. (Alloy Steel Div.) ..... 181
Republic Steel Corp. (Steel & Tubes Div.) ..... 173
Revere Copper & Brass Inc. ..... 8
Reynolds Wire Co. ..... 187
Robbins & Myers Inc. ..... 225
Rockford Clutch Div., Borg-Warner ..... 310
Roebling's Sons Co., John A. ..... 185
Roper Corp., Geo. D. ..... 338
Reliance Electric & Engineering Co. ..... 273

Schrader's Sons Div., A., Scovill D. Mfg. Co. ..... 248
Scintilla Magneto Div., Bendix Aviation Corp., Electrical Connectors ..... 63
Scintilla Magneto Div., Bendix Aviation Corp., H. & K. Magnetos ..... 67
Scovill Mfg. Co. (Industrial Fasteners) ..... 272
Sewall Mfg. Co., E. B. ..... 214
Seymour Mfg. Co., The ..... 241
Sharon Steel Corp. ..... 209
Shenango-Penn Mold Co. ..... 210
Skinner Purifiers Div., of Bendix Aviation Corp. ..... 268
Smith Corp., A. O. ..... 205
Society of the Plastics Industry ..... 252
Society of Tool Engineers ..... 258
South Chester Corp. ..... 337
Spencer Thermostat Division Metal & Controls Corp. ..... 49
Sponge Rubber Products Co. ..... 254
Square D Company ..... 36-37
Stalwart Rubber Co. ..... 284
Standard Pressed Steel Co. ..... 38
Standard Products Co. ..... 249
Sterling Electric Motors, Inc. ..... 312
Stewart Warner ..... 203
Stokes Machine Co., F. J. ..... 292
Stow Mfg. Co. ..... 272

Telechron Inc. ..... 323
Thomas Flexible Coupling Co. ..... 208
Thomson Industries, Inc. ..... 224
Timken Roller Bearing Co (Industrial) ..... 48C
Timken Roller Bearing Co (Steel & Tubes) ..... 175
Tinnerman Products, Inc. ..... 78
Tomkins-Johnson Co. ..... 287
Topflight Tape Co. ..... 316
Torrington Co. (Needle Bearings) 77
Torrington Co. ..... 204
Tuthill Pump Co. ..... 280
Twin City Die Casting Co. ..... 218
Twin Disc Clutch Co. ..... 64B

Union Carbide & Carbon Corp. ..... 48D, 65
Union Chain & Mfg. Co. ..... 60-61

# INDEX TO ADVERTISERS


United Screw & Bolt Corp..... 177
U. S. Electrical Motors, Inc..... 252
U. S. Graphite Co...4th Cover, 44-45
U. S. Rubber Co..... 240
Universal Clay Products Co..... 304

Van Huffel Tube Corp..... 183
Veeder-Root Inc..... 17
Vickers, Inc..... 167
Viking Pump Co..... 320

Ward Leonard Electric Co....192-193
Warner Electric Brake Co..... 59
Washington Steel Corp..... 322
Welco Motors..... 316
Wellman Bronze & Aluminum Co. 242
Wesche Co., B. A..... 316
Western Felt Works..... 268
Westinghouse Electric Corp..... 39
Wheland Co..... 298
White Dental Mfg. Co., S. S.... 339
Whitney Chain & Mfg. Co..... 168
Wiggins Oil Tool Co., E. B..... 252
Williams & Co., J. H..... 332
Wirebound Box Mfgs. Assn..... 296
Wisconsin Motor Corp..... 308
Wolverine Tube Div., Calumet & Hecla Cons. Copper Co..... 290
Worcester Pressed Steel Co..... 76

Zenith Carburetor Div., Bendix Aviation Corp..... 274


■


PROFESSIONAL SERVICES ..... 334


■

SEARCHLIGHT SECTION
*(Classified Advertising)*


EMPLOYMENT
Positions Vacant ..... 334
Selling Opportunities Offered..... 334
Positions Wanted ..... 334
Employment Services ..... 334

SPECIAL SERVICES
Contract Work ..... 334

BUSINESS OPPORTUNITIES
Offered ..... 334

EQUIPMENT
(Used or Surplus New)
For Sale ..... 334


■


Product Index starts on..... 335
Advertisers' Index starts on..... 338



# Unique Fenwal Thermoswitch* Thermostat Amazes Heating Experts by Performing the "Impossible!"

**YES,** manufacturers are discovering the remarkable line of Fenwal THERMOSWITCH* units can give them help they thought mechanically impossible! A coal furnace manufacturer, for instance, found the Fenwal THERMOSWITCH* the *only* thermostat able to solve the problem of automatic grate shaking. Ordinary thermostats either could not stand up under punishment . . . or were too slow in operation.

You, too, can benefit from this unbeatable THERMOSWITCH* performance. It has countless applications, does away with costly control equipment, opens up new forms of precision-control in all types of manufacturing processes. Low upkeep cost, too. The THERMOSWITCH* is accurate, rugged and simply constructed, with mechanism fully enclosed by the temperature-sensitive shell. Investigate it now!

**FENWAL INCORPORATED**
23 Pleasant St., Ashland, Mass.
*Temperature Control Engineers*

Fenwal

WRITE FOR BULLETIN ON

**THERMOSWITCH***

*Reg. U. S. Pat. Off.

The Precision Thermostat For Temperature Control and Detection

SENSITIVE...*but only to heat*

# SIMPLIFY YOUR DRIVE LAYOUTS WITH VEELOS

## . . . and you can fit the belt to the machine . . . not the machine to the belt

YOU know the advantages of complete freedom of design when it comes to power delivery. Often machine efficiency can be stepped up by placing the motor in the most desirable position—but, because of the limitations of endless v-belts, this is not always possible.

With Veelos, the adjustable v-belt, no such limitations exist. In addition, sliding and pivoted type motor bases are not needed. Idlers are not necessary for belt take-up on fixed center drives. Outboard bearings can be used where required and Veelos can be installed without dismantling any part of the machine.

Correct belt tension, important for full, smooth power transfer, is another plus factor found in Veelos.

Veelos is made in all standard widths: 00, 0, A, B, C, D and E. It is available in three types: regular, oil-proof and static conducting. Also Veelos double V in A and B widths.

You are invited to consult our engineers on your particular v-belt needs and we believe you will find it advantageous to do so. If you do not have a copy of the Veelos Data Book let us send one on to you immediately.

MANHEIM MANUFACTURING & BELTING COMPANY • MANHEIM, PA.

VEELOS
THE LINK
V-BELT

**ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE**

Made in all standard sizes, fits all standard grooves. Packaged on reels in 100-foot lengths. Sales engineers in principal cities. Veelos is known as VEELINK outside the United States.

On thousands of applications in every field of manufacture, stepless variable speed operation assures exactly the right speed for every operation . . . for every operator . . . the right speeds for each change in the consistency or shape of the material being processed. Such variable speed operation pays off in higher rates of production, a more uniform better quality product and more efficient performance of your equipment and your operators.

Master Speedrangers provide this infinitely variable speed in a compact, all-metal, mechanical variable speed unit whose durability and stamina has been proven with millions of hours of service all over the world. And nowhere else will you find units that are so flexible, so easily adaptable and in such a wide range of sizes.

For example, look at the machine shown below. The Speedranger on the drive unit incorporates an electric motor, a variable speed unit and a gear reduction . . . all standard Master units that easily combine into one compact, integral power package. This provides exactly the right speed, the right features, in a unit that you can mount right where you want it.

# IT PAYS

Probably you will not need this same combination of features. However, the next time you need a drive for material processing, handling, and conveying equipment; mixers and agitators; welding positioners; machine tool drives; testing and calibrating equipment . . . to name only a few . . . see what a really remarkable job Master Speedrangers can do for you. Write for Data 7525, new twenty-four page booklet on Speedrangers.

**THE MASTER ELECTRIC COMPANY**
**DAYTON 1, OHIO**

MASTER SPEEDRANGERS

# These **GRAMIX** parts of intricate design, in quantity production, cost only 1¢ to 17¢ each

die pressed of powdered iron or bronze to within .0005"
eliminate costly machining time
oil impregnated for self lubrication

## GRAMIX

THE UNITED STATES GRAPHITE COMPANY • SAGINAW, MICHIGAN
DIVISION OF THE WICKES CORPORATION